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ABSTRACT

Teacher and student editions of Civil Technology Applications are one in a series of competency-based instructional materials for drafting and civil technology programs. It includes the technical content and tasks necessary for a student to be employed as a drafter or civil technician in a civil engineering firm. Introductory pages in the teacher edition are training and competency profile, instructional/task analysis; basic skills icons and classifications; basic skills matrix; and tools, equipment, and materials list. Teacher pages include suggested activities, answers to assignments, written test with answers, learning activities sheets, teacher supplements, and transparency masters. The 12 units are introduction to civil technology applications; map scales and measurement; computer applications in the civil engineering field; standard symbols and abbreviations; map projections, reference systems, and legal land descriptions; interpretation of surveyor's notations; topographic mapping; municipal mapping, plats, and subdivisions; transportation mapping; structural drafting; construction surveying; and procedures for the preparation of maps and plans. The student edition contains some or all of these components for each unit: unit contents, objective sheet, information sheet, student supplements, assignment sheets, and job sheets. (YLB)

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Civil Technology Applications. Teacher Edition [and] Student Edition

Karen Schertz

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MAVCC

Teacher Edition

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Civil Technology Applications

Teacher Edition

Written by

Karen Schertz

Project coordinated by

Jane Huston

Developed by

The Multistate Academic and Vocational Curriculum Consortium, Inc.

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Units of Instruction

Unit 1: Introduction to Civil Technology Applications

Unit 2: Map Scales and Measurement

Unit 3: Computer Applications in the Civil Engineering Field

Unit 4: Standard Symbols and Abbreviations

Unit 5: Map Projections, Reference Systems, and Legal Land Descriptions

Unit 6: Interpretation of Surveyor's Notations

Unit 7: Topographic Mapping

Unit 8: Municipal Mapping, Plats and Subdivisions

Unit 9: Transportation Mapping

Unit 10: Structural Drafting

Unit 11: Construction Surveying

Unit 12: Procedures for the Preparation of Maps and Plans

Appendix

MAVCC Topographic Survey Answers/Solutions

Foreword

Civil Technology Applications, a major revision of *Civil Drafting*, ©1986, is one in a series of competency-based instructional materials for drafting programs developed by the Multistate Academic and Vocational Curriculum Consortium (MAVCC). This publication is designed to include the technical content and tasks necessary for a student to be employed as a drafter or civil technician in a civil engineering firm, and complements MAVCC's core drafting publication, *Basic Drafting*.

Additional materials developed for the specialized areas of drafting include the following:

- *Mechanical Drafting with CAD*
- *PC Board Layout and Electronic Drafting with CAD*
- *Pipe Drafting with CAD*
- *Architectural Drafting: Commercial Applications*

Designed for student use and to assist teachers in organizing and improving instruction, these instructional materials are based on the curriculum-alignment concept of first stating the objectives (objective sheet), developing instructional strategies for teaching to those objectives (information, assignment, and job sheets), and assessing to those same objectives (written test).

Every effort has been made to make these materials basic, readable, and by all means, usable. However, with all MAVCC publications, teachers are encouraged to supplement, localize and personalize the instructional materials to meet industry and individual student needs, and to develop strategies for motivating their students.

Special attention should be given to the matrix identifying basic academic and workplace skills being reinforced in these instructional materials. By reinforcing these skills, the instructor should assist students in improving their employability skills.

As you use these instructional materials, we hope that you will find that they contribute to the quality of your program.

Mervin Birdwell, Chair
Board of Directors
Multistate Academic and
Vocational Curriculum
Consortium

Clark R. Harris
Executive Director
Multistate Academic and
Vocational Curriculum
Consortium

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Thanks are also extended to Cheryl Barr for her assistance in editing this publication, to Stacy Lee for her assistance in electronic publishing and in creating artwork for this publication, and to the employees of the Graphics Division of the Oklahoma Department of Career and Technology Education for printing this publication.

Use of This Publication

Civil Technology Applications is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the Civil Drafting and Surveying Advisory Committee, comprised of business/industry representatives and teachers.

Teacher Edition

The complete teacher edition consists of introductory pages, teacher pages, a CD-ROM that includes MAVCC Topographic Survey Point File and answers, and the student edition. Materials are loose-leaf and three-hole punched and are divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit is individually numbered beginning with a T for teacher page, followed by the unit number and page number.

Example:

Page 17 of Unit 3 in the teacher pages are represented as T 3–17.

MAVCC—*Civil Technology Applications* T 3–17

Page 1 of Unit 5 in the teacher pages are represented as T 5–1.

MAVCC—*Civil Technology Applications* T 5–1

Pages in the student edition are numbered beginning with the unit number, followed by the page number.

Example:

Page 7 of Unit 5 in the student edition is represented as Page 5–7.

MAVCC—*Civil Technology Applications* Page 5–7

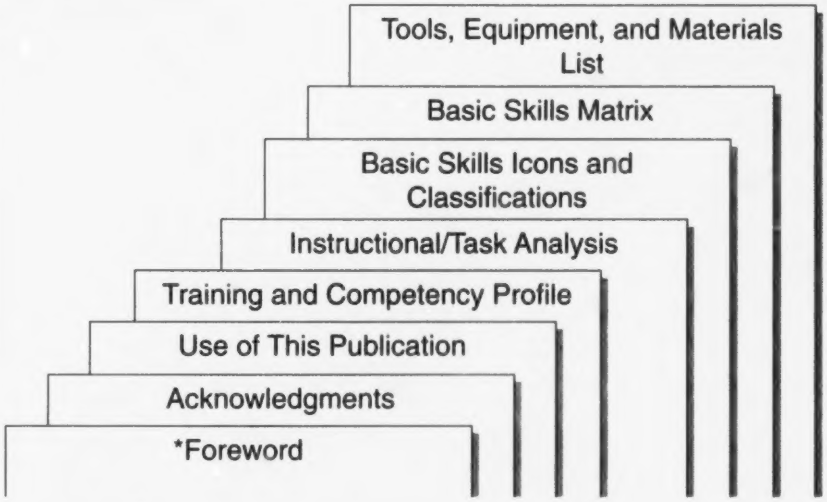
Use of This Publication

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages


Tools, Equipment, and Materials List
Basic Skills Matrix
Basic Skills Icons and Classifications
Instructional/Task Analysis
Training and Competency Profile
Use of This Publication
Acknowledgments
*Foreword

*Designates items that may not appear in every publication

Use of This Publication

In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

- ☐ **Training and Competency Profile.** This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.

- ☐ **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.

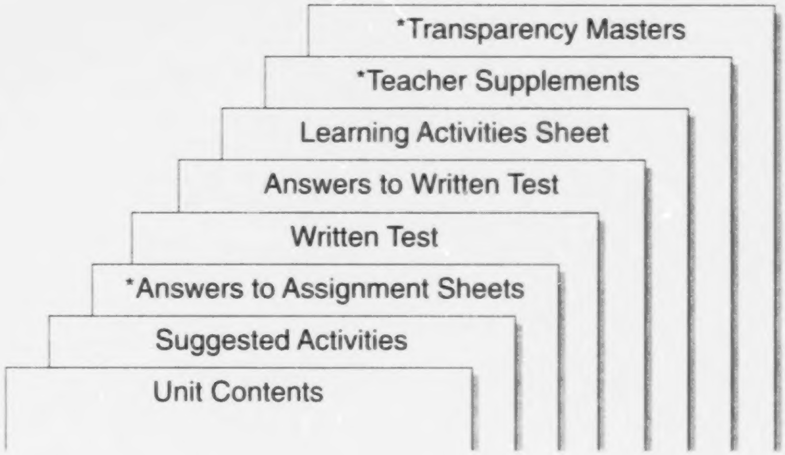
- ☐ **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each focus assignment, assignment sheet, and job sheet.

- ☐ **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.

- ☐ **Tools, Equipment, and Materials List.** This document provides a comprehensive list of those items needed in a vocational program for students to complete training. It also can assist administrators and teachers in determining program costs.

Use of This Publication

Teacher Pages


*Transparency Masters
*Teacher Supplements
Learning Activities Sheet
Answers to Written Test
Written Test
*Answers to Assignment Sheets
Suggested Activities
Unit Contents

*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

☐ **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

☐ **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

☐ **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

☐ **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

☐ **Learning Activities Sheet.** This component provides a model for teachers to use in implementing a self-paced or individualized program, and guides the student through the required components in the student edition (objective sheet, information sheet, student supplements, assignment sheets, and job sheets). The teacher should modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student. Final copies should be distributed for student use.

The following icons will be used on the learning activities sheet to denote steps that require additional resources:

📖 Read a book, magazine, or journal article

💻 Use a CBT program or other software application

WWW Access a site on the World Wide Web

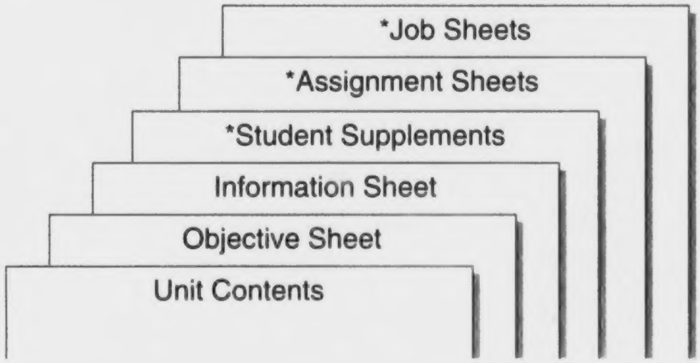
🖥 Look at PowerPoint® or other computer presentation

📼 Watch a videotape

☐ **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

☐ **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Edition



*Designates components that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

☐ **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

☐ **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

☐ **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

☐ **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. A student point file for the MAVCC topo. survey assignments has been provided on CD-ROM. Criteria are provided to evaluate student performance objectively.

☐ **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, or E-mail us at mavcc@mavcc.com.

Training and Competency Profile

Student Information

Program ____________________ Instructor ____________________

Name ____________________ Soc. Sec. No. ____________________

Address ____________________ Phone ____________________

Grade ____________________ School ____________________

Allergies/Disabilities that might require special accommodation for training (please specify)

____

In case of emergency, contact ____________________ Phone ____________________

Record of Enrollment

Date of Enrollment ____- ____- ____ Total Class Hours________ Total Hours Absent________

Date of Withdrawal ____- ____- ____ Total On-the-Job Training Hours________ Total Hours Tardy________

Date of Completion ____- ____- ____ Total Lab Hours________

On-the-Job Training/Work Experience

Place of Employment ____________________ Address ____________________

Supervisor's Name ____________________ Phone ____________________

Duration of Employment ____________________ Job Title ____________________

Job Responsibilities ____________________

Place of Employment ____________________ Address ____________________

Supervisor's Name ____________________ Phone ____________________

Duration of Employment ____________________ Job Title ____________________

Job Responsibilities ____________________

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Rating Scale: Option A

4	Skilled—Can perform job with no additional training
3	Moderately Skilled—Has performed job during training program; limited additional training may be required.
2	Limited Skill—Has performed job during training program; additional training is required to develop skill.
1	Unskilled—Is familiar with process, but is unable to perform job.
0	No Exposure—No information or practice provided during training program, complete training required.
NA	Non-applicable.

Rating Scale: Option B

Yes—Can perform with no additional training
No—Is unable to perform satisfactorily

Unit 1: Introduction to Civil Technology Applications

_______ 1. Interview a Civil Technician
_______ 2. Research Possible Employment Opportunities in Civil Drafting Technology in Your Local Area
_______ 3. Access the Internet for Mapping Resources
_______ 4. ______________________________

Written Test Scores
Pretest Score _________ %
Posttest Score _________ %

Unit 2: Map Scales and Measurement

_______ 1. Convert a Representative Fraction to a Graphic Scale
_______ 2. Measure With a Civil Engineer's Scale
_______ 3. Measure Distances on a 7.5 Minute Quadrangle
_______ 4. Use a Civil CAD Software Program to Set Project Parameters
_______ 5. ______________________________

Written Test Scores
Pretest Score _________ %
Posttest Score _________ %

Unit 3: Computer Applications in the Civil Engineering Field

_______ 1. Research Available CAM Software and the Hardware Requirements
_______ 2. Research Computer Applications in the Civil Engineering Field
_______ 3. Import and Print Out an ASCI Point File Using a Civil CAD Software Program
_______ 4. ______________________________

Written Test Scores
Pretest Score _________ %
Posttest Score _________ %

Unit 4: Standard Symbols and Abbreviations

_______ 1. Set Up a Map Legend
_______ 2. Locate and Identify Symbols and Features on a USGS Map
_______ 3. ______________________________

Written Test Scores
Pretest Score _________ %
Posttest Score _________ %

Unit 5: Map Projections, Reference Systems, and Legal Land Descriptions

_______ 1. Answer Questions Based on the U.S. Public Land Survey System
_______ 2. Write and Locate Descriptions for the Subdivision of a Section
_______ 3. Write a Lot and Block Description
_______ 4. Identify Components Used to Develop a Plat
_______ 5. Identify Geographic Coordinates on a USGS Quadrangle Map
_______ 6. Scale on a UTM Grid
_______ 7. ______________________________

Written Test Scores
Pretest Score _________ %
Posttest Score _________ %

Unit 6: Interpretation of Surveyor's Notations

______ 1. Plot Lines and Distances Using Several Methods
______ 2. Convert Azimuths to Bearings and Bearings to Azimuths
______ 3. Lay Out a Closed Traverse
______ 4. Complete a Mathematical Closure of a Traverse
______ 5. Reduce Four Types of Field Notes
______ 6. Draw a Map Using Bearings, Distances, and Coordinates
______ 7. Lay Out the Property Boundary for the MAVCC Topographic Survey Map
______ 8. ______________________________

Written Test Scores
Pretest Score ________ %
Posttest Score ________ %

Unit 7: Topographic Mapping

______ 1. Use a Polar Planimeter to Determine Acreage
______ 2. Interpolate Contours From a Grid Survey and Prepare Profiles From the Contour Map
______ 3. Calculate Grades
______ 4. Build a TIN and Make Contours
______ 5. ______________________________

Written Test Scores
Pretest Score ________ %
Posttest Score ________ %

Unit 8: Municipal Mapping, Plats and Subdivisions

______ 1. Lay Out a Boundary Survey From a Legal Description
______ 2. Reduce Field Notes and Plot a Simple Boundary Survey
______ 3. Develop From Field Notes the Plat Map for a Nine-Lot Subdivision
______ 4. Redraw to Scale a Complete Final Plat of a 36-Lot Subdivision
______ 5. Research the Plat Information for Your Property or a Property in Your Area
______ 6. Research the Plats for Local Utilities
______ 7. ______________________________

Written Test Scores
Pretest Score ________ %
Posttest Score ________ %

Unit 9: Transportation Mapping

______ 1. Lay Out Open Traverses Using Several Methods
______ 2. Lay Out a Survey Alignment for a Road Using Bearings and Coordinates
______ 3. Calculate the Bearing, Slope, % Grade, True Length, and Azimuth of the ℄ of a Highway
______ 4. Develop a Plan and Profile and Cross Sections, and Determine Cut and Fill for a Road Alignment
______ 5. ______________________________

Written Test Scores
Pretest Score ________ %
Posttest Score ________ %

Unit 10: Structural Drafting

______ 1. Prepare Detail Drawings of Structural Steel Members
______ 2. Draw to Scale a Concrete Engineering Drawing
______ 3. Detail a Wood Truss
______ 4. ______________________________

Written Test Scores
Pretest Score ________ %
Posttest Score ________ %

Unit 11: Construction Surveying

______ 1. Develop Multiple Profiles to Determine Total Volume of Earthwork
______ 2. Establish a Grade Plan and Determine Cut and Fill for a Cabin Site
______ 3. Develop a Grading Plan for the MAVCC Topographic Survey Site
______ 4. ______________________________

Written Test Scores
Pretest Score ________ %
Posttest Score ________ %

Unit 12: Procedures for the Preparation of Maps and Plans

______ 1. Complete a Tracing in Ink of a Mapped Area
______ 2. Prepare a Final Presentation of the MAVCC Topographic Survey Map
______ 3. Use a Polar Planimeter to Determine Acreage
______ 4. ______________________________

Written Test Scores
Pretest Score ________ %
Posttest Score ________ %

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 1: Introduction to Civil Technology Applications

1. Terms and definitions
2. Required skills of a civil technician
3. Job responsibilities of a civil technician
4. Major employment opportunities for a civil technician
5. Organization structures of design teams in small and large firms
6. Specialty areas for civil engineering firms
7. Occupations related to civil drafting
8. Major types of maps
9. Characteristics of maps
10. Typical drawings used in civil drafting
11. Drafting equipment used by civil technicians
12. Interview a civil technician
13. Research possible employment opportunities in civil drafting technology in your local area
14. Access the Internet for mapping resources

Unit 2: Map Scales and Measurement

1. Terms and definitions
2. Chart of standard measures and their equivalents
3. Accuracy and precision
4. Choosing a map scale
5. Characteristics of map scales
6. Ways map scales are expressed
7. Ranges of map scales
8. Factors affecting the selection of a map scale
9. Common types of maps and corresponding map scales
10. Definition of a minute on the globe
11. Characteristics of a quadrangle scale

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2: Map Scales and Measurement (continued)

12. Quadrangle scales commonly used on USGS topographic maps
13. Characteristics of graphic scales
14. Published map accuracy standards
15. Scales used in civil drafting
16. Map scale in CAD

17. Convert a representative fraction to a graphic scale
18. Measure with a civil engineer's scale
19. Measure distances on a 7.5 minute quadrangle
20. Use a civil CAD software program to set project parameters

Unit 3: Computer Applications in the Civil Engineering Field

1. Terms and definitions
2. Basic CADD operations
3. Advantages of computer applications in mapping
4. Definition of digital cartography
5. Types of geographic or land systems that utilize digital data information
6. Types of digital cartographic and geographic data
7. Characteristics of digital cartographic and geographic data
8. Types of computer aided map (CAM) software
9. Features of main civil software modules
10. Setting parameters for a computer mapping project
11. Other types of digital or computer enhanced mapping tools

12. Research available CAM software and the hardware requirements
13. Research computer applications in the civil engineering field
14. Import and print out an ASCI point file using a civil CAD software program

Unit 4: Standard Symbols and Abbreviations

1. Terms and definitions
2. Types of symbols commonly used in civil drafting
3. Abbreviations used on public land surveys
4. Abbreviations used on construction surveys
5. Abbreviations used on property surveys

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 4: Standard Symbols and Abbreviations (continued)

6. Symbols commonly used in surveying
7. Factors that determine when an abbreviation should be used
8. Purposes of symbols on maps
9. USGS topographic map symbols
10. Other conventional topographic symbols
11. Boundary, fence, and track fixture symbols
12. Civil symbols
13. Utility and service symbols
14. Hydrographic and navigation symbols
15. Geological structure symbols
16. Oil and gas symbols
17. North arrow symbols
18. General rules for drawing map symbols
19. Methods used in drawing symbols
20. Colors of map symbols
21. Common material symbols used in structural and architectural drawings
22. Standard symbols for pipe fittings
23. Set up a map legend
24. Locate and identify symbols and features on a USGS map

Unit 5: Map Projections, Reference Systems, and Legal Land Descriptions

1. Terms and definitions
2. Concepts that are fundamental to map projections and reference systems
3. Factors in the selection of a map projection
4. Projections used by the U.S. Geological Survey (USGS)
5. Methods of legal land descriptions
6. Facts to understand about coordinate systems
7. United States Public Land Survey (USPLS) System
8. Subdivision of a section

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 5: Map Projections, Reference Systems, and Legal Land Descriptions (continued)

9. Lot and block descriptions
10. Metes and bounds descriptions
11. Components used to develop a plat
12. State plane coordinates
13. Legal aspects of land acquisition
14. Types of boundary classifications
15. Boundary precedence
16. Types of geographic coordinates found on a USGS quadrangle map
17. BLM Land Information System

18. Answer questions based on the U.S. Public Land Survey System
19. Write and locate descriptions for the subdivision of a section
20. Write a lot and block description
21. Identify components used to develop a plat
22. Identify geographic coordinates on a USGS quadrangle map
23. Scale on a UTM grid

Unit 6: Interpretation of Surveyor's Notations

1. Terms and definitions
2. Six activities identified by the International Federation of Surveyors that help define surveying
3. Classifications of surveys
4. Types of surveys
5. Types of computer-based digital data files
6. U.S. government agencies that perform surveying
7. Types of measurements used in surveying
8. Important characteristics in surveying measurement
9. Accuracy and precision
10. Accuracy ratio
11. Types of errors
12. Types of surveying equipment
13. Methods used in surveying to measure horizontal distances
14. Methods used to determine horizontal point positions
15. Triangulation

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 6: Interpretation of Surveyor's Notations (continued)

16. Traverses
17. Direction of a line/course by bearings or azimuths
18. Conversion of azimuths to bearings and bearings to azimuths
19. Methods of plotting traverses
20. Vertical angles
21. Definition of leveling
22. Basic leveling terminology
23. Reference elevations
24. Equipment that can be used to level
25. Steps in developing and plotting a profile from profile leveling notes
26. Stationing
27. Field notes
28. Arrangement of field notes in the field book
29. Electronically recorded notes
30. Global positioning systems (GPS)
31. How GPS works
32. Benefits of surveying with GPS
33. General applications of GPS
34. GPS procedures

35. Plot lines and distances using several methods
36. Convert azimuths to bearings and bearings to azimuths
37. Lay out a closed traverse
38. Complete a mathematical closure of a traverse
39. Reduce four types of field notes
40. Draw a map using bearings, distances, and coordinates
41. Lay out the property boundary for the MAVCC topographic survey map

Unit 7: Topographic Mapping

1. Terms and definitions
2. Definition of topographic analysis
3. Types of maps that show relief
4. Uses for topographic maps
5. Definition of topographic survey
6. Types of surveys used in topographic mapping
7. Field methods for locating topographic details, planimetric features, and contours

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 7: Topographic Mapping (continued)

8. Factors affecting the selection of the field method to be used for a topographic map
9. Controls for topographic surveys
10. Characteristics of benchmarks (BM)
11. Steps in laying out a topographic survey
12. Digital elevation model (DEM)
13. Basic geometric configurations that are used in the field for collecting DEM data
14. Breaklines
15. Characteristics of a triangulated irregular network (TIN) when used for an automated contouring network
16. National standards for accuracy on topographic maps
17. Scales for topographic map series—USGS
18. Selection of contour intervals
19. Characteristics of contour lines
20. Characteristics of hachures
21. Typical contour line configurations

22. Use a polar planimeter to determine acreage
23. Interpolate contours from a grid survey and prepare profiles from the contour map
24. Calculate grades
25. Build a TIN and make contours

Unit 8: Municipal Maps, Plats and Subdivisions

1. Terms and definitions
2. Definition of subdivision planning
3. Official agents who may regulate subdivision planning
4. Elements to consider when developing a parcel of land
5. Resource maps and documents used in land development
6. Types of plans
7. Types of utilities
8. Agencies that develop and maintain municipal maps
9. Users of municipal maps

Unit 8: Municipal Maps, Plats and Subdivisions (continued)

Related Information: What the Student Should Know

10. Types of drawings used in municipal mapping
11. Methods of presenting utilities on maps
12. Support information needed to develop utility drawings for a specific area
13. Color codes used to represent different utilities
14. Utility easements
15. Information included on utility drawings
16. Types of valves and valve housings
17. Types of sewers and sewer lines
18. Information related to water lines
19. Types of gas piping and devices
20. Geologic report
21. Soils report
22. Purpose of a site analysis
23. Items to consider when conducting a site analysis
24. Reports and permits required for a development site
25. Steps in planning a subdivision
26. The final recordation of a subdivision plat map
27. Individuals who certify and approve a final plat mat
28. Characteristics of legal descriptions
29. Geographic Information Systems (GIS)
30. Applications for GIS
31. Advantages to GIS
32. What makes GIS work
33. GIS and data integration

Application: What the Student Should Be Able to Do

34. Lay out a boundary survey from a legal description
35. Reduce field notes and plot a simple boundary survey
36. Develop from field notes the plat map for a nine-lot subdivision
37. Redraw to scale a complete final plat of a 36-lot subdivision
38. Research the plat information for your property or a property in your area
39. Research the plats for local utilities

Instructional/Task Analysis

Unit 9: Transportation Mapping

Related Information: What the Student Should Know

1. Terms and definitions
2. Purpose of route surveys
3. Fundamentals of a route survey
4. Superelevated roadways
5. Elements of a horizontal circular curve
6. Mathematical formulas used for computing a horizontal curve
7. Circular curve layout by tangent offsets
8. Vertical curves
9. Plan views for route surveys
10. Characteristics of profiles for a route survey
11. Characteristics of cross sections for a route survey
12. Field note reduction for a cross section
13. Plotting cross sections
14. Methods used to determine areas of cross sections
15. Formulas for calculating earth volume
16. Steps for a road construction project
17. Drawings included in a set of highway plans
18. Horizontal and vertical scales used in transportation mapping for rural and urban areas
19. Items that appear on a typical title sheet for a set of highway plans
20. Detail sheets
21. Drafting of plan views, profiles, and cross sections

Application: What the Student Should Be Able to Do

22. Lay out open traverses using several methods
23. Lay out a survey alignment for a road using bearings and coordinates
24. Calculate the bearing, slope, % grade, true length, and azimuth of the ℄ of a highway
25. Develop a plan and profile and cross sections, and determine cut and fill for a road alignment

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 10: Structural Drafting

1. Terms and definitions
2. Definition of structural drawing
3. Types of structures
4. Types of materials used for structures
5. Types of rolled steel products
6. Types of steel members
7. Structural steel shapes
8. Drawing practices for steel members
9. Characteristics of shop drawings
10. Placement of gage lines for steel members
11. Fastener sizes and spacings
12. Dimensioning procedures for steel structures
13. Structural steel callouts
14. Structural steel marking
15. Steps a structural steel shape goes through in fabrication
16. Basic methods of fastening structural steel shapes
17. Precast concrete abbreviations
18. Types of cross section symbols for precast concrete
19. Anchor bolts
20. Types of concrete
21. Types of concrete reinforcement
22. Standard prestressed concrete units
23. Foundation parts
24. Types of structural drawings for concrete
25. Standard symbols and abbreviations for concrete placing drawings
26. Standard practices for documentation of rebar

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 10: Structural Drafting (continued)

27. Examples of typical details for concrete structures
28. Wood construction
29. Types of wood connectors
30. Types of framing connectors
31. Components of wood construction
32. Heavy timber construction

33. Prepare detail drawings of structural steel members
34. Draw to scale a concrete engineering drawing
35. Detail a wood truss

Unit 11: Construction Surveying

1. Terms and definitions
2. Definition of construction surveying
3. Types of surveys used for a construction project
4. Steps for placing a structure on a building site
5. Components of a site plan
6. Components of a final plot plan
7. Components of a preliminary construction survey
8. Purpose of a grading plan
9. Elements of a grading plan
10. Purpose of grade stakes
11. Steps taken to establish a grade stake
12. Factors in referencing points for construction
13. Steps taken to establish the required cut and fill for a building site

14. Develop multiple profiles to determine total volume of earthwork
15. Establish a grade plan and determine cut and fill for a cabin site
16. Develop a grading plan for the MAVCC topographic survey site

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 12: Procedures for the Preparation of Maps and Plans

1. Terms and definitions
2. Types of drafting media
3. Methods of drawing reproduction
4. Difference between a map and plan
5. Components of a map layout
6. Purpose of a legend
7. North (meridian) arrow
8. Scale and scale bar
9. Components of a title block
10. Steps for drafting a map or plan
11. Standard sheet format for a set of civil drawings
12. Methods of map registration
13. Lettering considerations for maps and plans
14. Useful tools for the creation and production of maps and plans
15. Types of planimeters
16. Parts of a polar planimeter
17. Applications of aerial photography
18. Advantages and disadvantages of using aerial photography
19. Aerial photo control
20. General facts about aerial photogrammetry
21. Steps for using a stereoscope
22. Common mistakes made in map drafting

23. Complete a tracing in ink of a mapped area
24. Prepare a final presentation of the MAVCC topographic survey map
25. Use a polar planimeter to determine acreage

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each focus assignment, assignment sheet, and job sheet.

A matrix for each of the ten broad skill areas has been included in this edition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000*, a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want*, a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources.

Each of the ten broad skill areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, critical thinking, employability, social studies, and technology—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development
- Resource Management
- Job Safety

Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

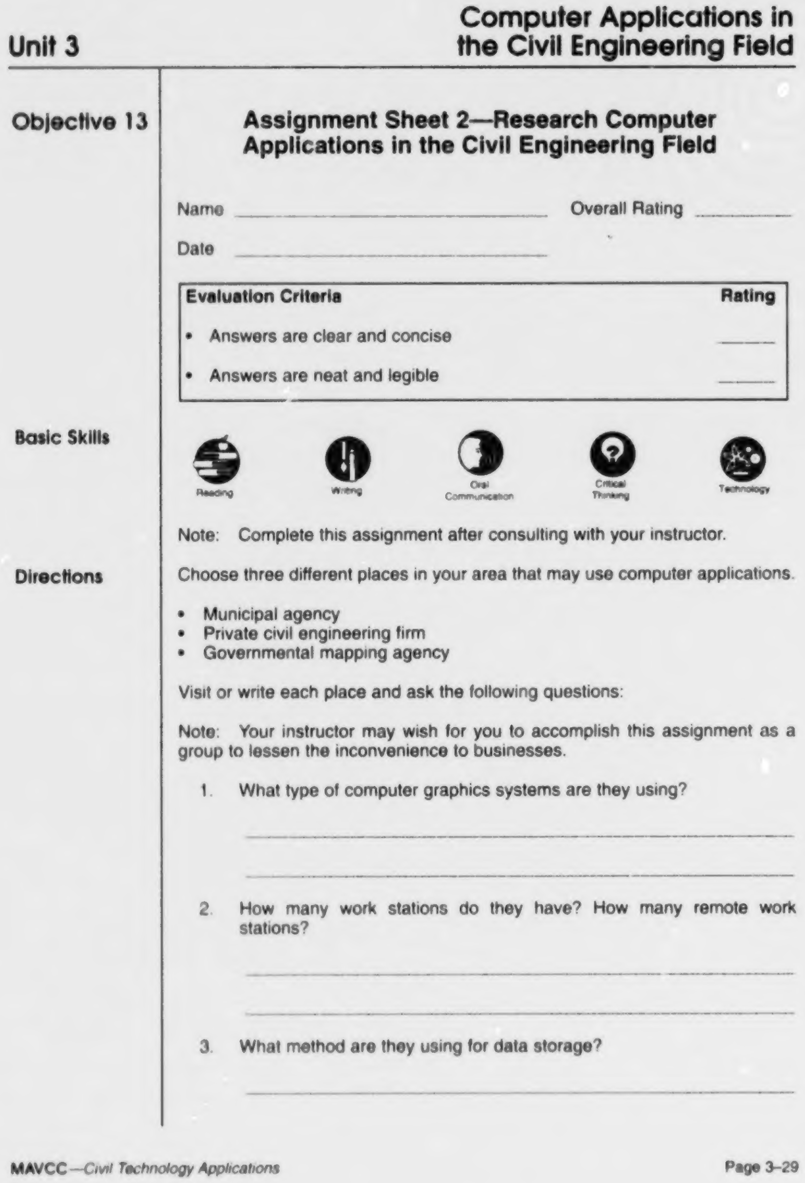
Technology Skills

- Selection
- Application
- Maintenance/Troubleshooting

Basic Skills Icons and Classifications

When an activity involving one of these basic skills is identified, the corresponding icon is on the assignment sheet and job sheet. Skills training is further defined by classifying specific skills that are required. (See skills list that may be found on the basic skills matrix.)

Example:



Unit 3 — **Computer Applications in the Civil Engineering Field**

Objective 13

Assignment Sheet 2—Research Computer Applications in the Civil Engineering Field

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	**Rating**
• Answers are clear and concise	_____
• Answers are neat and legible	_____

Basic Skills

Note: Complete this assignment after consulting with your instructor.

Directions

Choose three different places in your area that may use computer applications.

- Municipal agency
- Private civil engineering firm
- Governmental mapping agency

Visit or write each place and ask the following questions:

Note: Your instructor may wish for you to accomplish this assignment as a group to lessen the inconvenience to businesses.

1. What type of computer graphics systems are they using?

2. How many work stations do they have? How many remote work stations?

3. What method are they using for data storage?

MAVCC—*Civil Technology Applications* Page 3–29

Unit 1: Introduction to Civil Technology Applications

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
12	Interview a civil technician (A.S. 1)		Reading	Functional reading	Follow written instructions
			Writing	Language	State ideas clearly
			Oral Communication	Interactive communication	Conduct interview
				Listening	Apply active listening skills
			Employability	Job search/ selections	Investigate training requirements and benefits for a civil technician
			Critical Thinking	Cognitive activities	Collect/ record information
13	Research possible employment opportunities in civil drafting technology in your local area (A.S. 2)		Reading	Comprehension	Gain factual information
				Research/ references	Use standard references
			Writing	Functional writing	Complete forms; use content area vocabulary
			Oral Communication	Interactive communication	Apply questioning techniques
				Listening	Apply active listening skills
			Employability	Job search/ selections	Investigate employment prospects for a civil technician
			Critical Thinking	Cognitive activities	Collect/record information
14	Access the Internet for mapping resources (A.S. 3)		Reading	Comprehension	Gain factual information
			Writing	Functional writing	Complete forms; use content area vocabulary
			Critical Thinking	Cognitive activities	Collect/record information
			Technology	Application	Utilize Internet as a research tool

Basic Skills Matrix

Unit 2: Map Scales and Measurement

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
17	Convert a representative fraction to a graphic scale (A.S. 1)	●	Reading	Comprehension	Analyze and apply what has been read to a specific task
		●	Mathematics	Application	Apply techniques of scaling
18	Measure with a civil engineer's scale (A.S. 2)	●	Reading	Functional reading	Read measuring instrument
		●	Mathematics	Functional math	Make measurements
19	Measure distances on a 7.5 minute quadrangle (A.S. 3)	●	Reading	Comprehension	Gain factual information
		●	Mathematics	Functional math	Make measurements
20	Use a civil CAD software program to set project parameters (A.S. 4)	●	Reading	Functional reading	Follow written instructions
		●	Mathematics	Application	Apply techniques of scaling
		●	Technology	Application	Demonstrate proper operating procedures

Unit 3: Computer Applications in the Civil Engineering Field

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
12	Research available CAM software and the hardware requirements (A.S. 1)	●	Reading	Comprehension	Gain factual information
		●	Writing	Functional writing	Write responses
		●	Critical Thinking	Cognitive activities	Collect/record information
		●	Technology	Selection	Choose software that will produce desired results
13	Research computer applications in the civil engineering field (A.S. 2)	●	Reading	Functional reading	Follow written instructions
		●	Writing	Functional writing	Write responses/letter
		●	Oral Communications	Interactive communication	Apply questioning techniques
		●	Critical Thinking	Cognitive activities	Analyze/synthesize information
		●	Technology	Application	Learn how computer graphic system/ organization works
14	Import and print out an ASCI point file using a civil CAD software program (A.S. 3)	●	Reading	Comprehension	Analyze and apply what has been read to a specific task
				Functional reading	Follow written instructions
		●	Critical Thinking	Cognitive activities	Create a finished product
		●	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/ software program

Basic Skills Matrix

Unit 4: Standard Symbols and Abbreviations

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
23	Set up a map legend (A.S. 1)	📚	Reading	Functional reading	Interpret maps and symbols
		?	Critical Thinking	Cognitive activities	Create a finished product
24	Locate and identify symbols and features on a USGS map (A.S. 2)	📚	Reading	Functional reading	Interpret maps and symbols
		?	Critical Thinking	Cognitive activities	Draw conclusions

Basic Skills Matrix

Unit 5: Map Projections, Reference Systems, and Legal Land Descriptions

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
18	Answer questions based on the U.S. public land survey system (A.S. 1)	📚	Reading	Functional reading	Follow written instructions; interpret map
		💡	Critical Thinking	Cognitive activities	Draw conclusions
19	Write and locate descriptions for the subdivision of a section (A.S. 2)	📚	Reading	Functional reading	Follow written instructions
		💡	Critical Thinking	Cognitive activities	Draw conclusions
20	Write a lot and block description (A.S. 3)	📚	Reading	Functional reading	Follow written instructions
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
21	Identify components used to develop a plat (A.S. 4)	📚	Reading	Functional reading	Read maps and symbols
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
22	Identify geographic coordinates on a USGS quadrangle map (A.S. 5)	📚	Reading	Functional reading	Follow written instructions
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
23	Scale on a UTM grid (A.S. 6)	📚	Reading	Comprehension	Analyze and apply what has been read to a specific task
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation

Basic Skills Matrix

Unit 6: Interpretation of Surveyor's Notations

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
35	Plot lines and distances using several methods (A.S. 1)	√	Mathematics	Math application	Apply geometric principles; apply scaling techniques
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
36	Convert azimuths to bearings and bearings to azimuths (A.S. 2)	√	Mathematics	Math application	Apply geometric principles; apply scaling techniques
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
37	Lay out a closed traverse (A.S. 3)	√	Mathematics	Math application	Apply geometric principles; apply scaling techniques
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
38	Complete a mathematical closure of a traverse (A.S. 4)	📚	Reading	Comprehension	Analyze and apply what has been read to a specific task
		√	Mathematics	Math application	Apply geometric principles
				Operation and calculation	Make calculations; check results
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
39	Reduce four types of field notes (A.S. 5)	📚	Reading	Comprehension	Analyze and apply what has been read to a specific task
		√	Mathematics	Math application	Apply mathematical procedure
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
40	Draw a map using bearings, distances, and coordinates (A.S. 6)	📚	Reading	Comprehension	Analyze and apply what has been read to a specific task
		√	Mathematics	Math application	Apply geometric principles; apply scaling techniques
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation

Unit 6: Interpretation of Surveyor's Notations (continued)

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
41	Lay out the property boundary for the MAVCC topographic survey map (A.S. 7)	●	Reading	Comprehension	Analyze and apply what has been read to a specific task
		●	Mathematics	Math application	Apply geometric principles
		●	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/ software program

Basic Skills Matrix

Unit 7: Topographic Mapping

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
22	Use a polar planimeter to determine acreage (A.S. 1)	📖	Reading	Comprehension	Analyze and apply what has been read to a specific task
		🔢	Mathematics	Functional math	Make measurements using a measuring device
		💡	Critical Thinking	Cognitive activities	Collect/record information
23	Interpolate contours from a grid survey and prepare profiles from the contour map (A.S. 2)	📖	Reading	Comprehension	Analyze and apply what has been read to a specific task
		🔢	Mathematics	Math application	Apply mathematical procedure; apply scaling techniques
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
24	Calculate grades (A.S. 3)	📖	Reading	Comprehension	Analyze and apply what has been read to a specific task
		🔢	Mathematics	Math application	Apply geometric principles
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
25	Build a TIN and make contours (A.S. 4)	📖	Reading	Comprehension	Analyze and apply what has been read to a specific task
		🔢	Mathematics	Math application	Apply geometric principles
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
		⚛	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/software program

Basic Skills Matrix

Unit 8: Municipal Mapping, Plats and Subdivisions

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
34	Lay out a boundary survey from a legal description (A.S. 1)	📚	Reading	Comprehension	Analyze and apply what has been read to a specific task
		🔢	Mathematics	Math application	Apply scaling techniques
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
35	Reduce field notes and plot a simple boundary survey (A.S. 2)	📚	Reading	Functional reading	Follow written instructions
		🔢	Mathematics	Math application	Apply geometric principles
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
36	Develop from field notes the plat map for a nine-lot subdivision (A.S. 3)	📚	Reading	Comprehension	Analyze and apply what has been read to a specific task
		🔢	Mathematics	Functional math	Make measurements using a measuring device
				Math application	Apply scaling techniques
37	Redraw to scale a complete final plat of a 36-lot subdivision (A.S. 4)	📚	Reading	Comprehension	Analyze and apply what has been read to a specific task
		🔢	Mathematics	Math application	Apply scaling techniques
		💡	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
		⚛	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/software program
38	Research the plat information for your property or a property in your area (A.S. 5)	📚	Reading	Research/reference	Locate and use standard reference
		✏	Writing	Research	Record data/information
		💡	Critical Thinking	Cognitive activities	Collect/record information

Basic Skills Matrix

Unit 8: Municipal Mapping, Plats and Subdivisions (continued)

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
39	Research the plats for local utilities (A.S. 6)	📚	Reading	Research/ reference	Locate resources
		✎	Writing	Research	Record data/information
		?	Critical Thinking	Cognitive activities	Collect/record information
		⚛	Technology	Application	Access web sites on the internet

Unit 9: Transportation Mapping

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
22	Lay out open traverses using several methods (A.S. 1)	●	Reading	Comprehension	Analyze and apply what has been read to a specific task
		●	Mathematics	Application	Apply geometric principles; apply scaling techniques
		●	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/ software program
23	Lay out a survey alignment for a road using bearings and coordinates (A.S. 2)	●	Reading	Comprehension	Analyze and apply what has been read to a specific task
		●	Mathematics	Application	Apply geometric principles; apply scaling techniques
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
24	Calculate the bearing, slope, % grade, true length, and azimuth of the ℄ of a highway (A.S. 3)	●	Reading	Functional reading	Interpret maps
		●	Mathematics	Application	Make measurements; apply geometric principles
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
25	Develop a plan and profile and cross sections, and determine cut and fill for a road alignment (A.S. 4)	●	Reading	Functional reading	Follow written directions
		●	Mathematics	Application	Make measurements; apply scaling techniques
		?	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation

Basic Skills Matrix

Unit 10: Structural Drafting

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
33	Prepare detail drawings of structural steel members (A.S. 1)	●	Reading	Functional reading	Follow written directions
		●	Mathematics	Application	Prepare drawings to scale
		●	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
		●	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/ software program
34	Draw to scale a concrete engineering drawing (A.S. 2)	●	Reading	Functional reading	Follow written directions; interpret plans
		●	Mathematics	Application	Prepare drawing to scale
		●	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
		●	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/ software program
35	Detail a wood truss (A.S. 3)	●	Reading	Comprehension	Analyze and apply what has been read to a specific task
		●	Mathematics	Application	Prepare drawing to scale
		●	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
		●	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/ software program

Unit 11: Construction Surveying

Academic and Workplace Skills

Obj. #	Objective	Icon	Skill	Sub Skill	Description
14	Develop multiple profiles to determine total volume of earthwork (A.S. 1)		Reading	Functional reading	Follow written directions
			Mathematics	Application	Make measurements; apply scaling techniques
			Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
15	Establish a grade plan and determine cut and fill for a cabin site (A.S. 2)		Reading	Functional reading	Follow written directions
			Mathematics	Functional math	Make calculations
				Application	Apply scaling techniques
			Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
16	Develop a grading plan for the MAVCC topographic survey site (A.S. 3)		Reading	Functional reading	Follow written directions
			Mathematics	Application	Apply geometric principles; apply scaling techniques
			Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
			Technology	Application	Demonstrate the proper procedure for setting up and operating computer/software program

Basic Skills Matrix

Unit 12: Procedures for the Preparation of Maps and Plans

Academic and Workplace Skills					
Obj. #	**Objective**	**Icon**	**Skill**	**Sub Skill**	**Description**
23	Complete a tracing in ink of a mapped area (A.S. 1)	●	Reading	Functional reading	Follow written directions
		●	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
24	Prepare a final presentation of the MAVCC topographic survey map (A.S. 2)	●	Reading	Functional reading	Follow written directions
		●	Critical Thinking	Cognitive activities	Transfer knowledge/training to a new situation
		●	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/ software program
25	Use a polar planimeter to determine acreage (J.S. 1)	●	Reading	Comprehension	Analyze and apply what has been read to a specific task
		●	Mathematics	Functional math	Make measurements using a measuring device
		●	Critical Thinking	Cognitive activities	Collect/record information
		●	Technology	Application	Demonstrate the proper procedure for setting up and operating computer/ software program

Tools, Equipment, and Materials List

CAD software program
CD-ROMs (teacher and student disks provided with this publication)
Civil engineer's scale
Computer hardware/system
Ink
Internet access
Maps
- A 7.5 minute USGS quadrangle map for student use in Unit 2, Assignment Sheet 2
- A 7.5 minute USGS quadrangle map for student use in Unit 5, Assignment Sheets 1 and 6
- Plat maps of subdivisions in your area for student use in Unit 5, Assignment Sheet 4
- A 7.5 minute USGS quadrangle map for student use in Unit 5, Assignment Sheet 5
- Plat maps of local property for student use in Unit 8, Assignment Sheet 5 (if students are unable to make on-site visit to local Planning Commission)

Metric coordinate reader
Paper
Pencil
Plans
Polar planimeter
Red color pencil
Sticky notes
Vellum

Unit Contents

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Unit Contents

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1—Interview a Civil Technician 1–47
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Instructional Plan

Suggested Activities

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Have students complete Student Supplement 1, "Math Assessment." Evaluate their knowledge, then provide students with help as indicated on assessment.
- Have students write and request different types of maps of your local area available through government agencies.
- Have students go on-line and browse through the different web sites listed in the resource section and Student Supplement 4.
- Take students on a field trip to a large civil engineering firm to observe the different types of civil projects being done.
- Invite a civil technician to class to talk about working in the field of engineering and its job duties and educational requirements.
- Invite a civil engineer to class to speak about requirements expected of a civil technician such as math and CAD skills.
- Demonstrate to students special CAD software packages as they apply to civil drafting.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- Brown, Walter and Clois E. Kicklighter. *Drafting for Industry.* South Holland, IL: Goodheart-Willcox Company, Inc., 1995.
- Colley, Barbara C. *Practical Manual of Land Development*, 3rd ed. New York: McGraw-Hill, Inc., 1998.
- *Definitions of Surveying and Associated Terms.* American Congress on Surveying and Mapping and the American Society of Civil Engineers. (out of print)
- Korte, George B. *The GIS Book*, 4th ed., Santa Fe, NM: OnWord Press, 1997.
- Madsen, David and Terence Shumaker. *Civil Drafting Technology,* 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1997.
- Thompson, Morris M. *Maps for America*, 3rd ed., USGS, United States Department of the Interior, 1987. (out of print)
- Wattles, Gurdon. *Survey Drafting*, 2nd ed. Orange, CA: Gurdon H. Wattles Publications, 1981.
- Wirshing, Roy and James Wirshing. *Civil Engineering Drafting.* New York: Glencoe/McGraw-Hill, Inc., 1983, imprint 1993.

Suggested Supplemental Resources

Electronic Media

- GIS Software Information

  Internet Access: Autodesk—The Map Guide Technology Web Page

  http://www.mapguide.com

  Note: This resource provides client/server framework to access GIS technology; suitable to wide range of users; interactive; 1996.

- National Mapping Program
  - National Map Atlas Maps

    USGS Map Sales
    Box 25286
    Denver, CO 80225
    (303) 236-7477
    (800) USA-MAPS

  - Earth Science Information Center

    EARTHFAX—Fax-on-demand system is available 24 hours a day at (703) 648-4888

Suggested Activities

- Cartographic Data on CD-ROM
- U.S. Geo Data (GIS)
- Aerial Photographs and Satellite Images
- Land Use and Land Cover and Associated Maps
- Topographic Map Information
- Separates

Answers to Student Supplement 1—Math Assessment

Part A

1. a. $\frac{13}{4}$
   b. $\frac{9}{2}$
   c. $\frac{22}{3}$
   d. $\frac{17}{2}$
   e. $\frac{20}{3}$
   f. $\frac{5}{2}$
   g. $\frac{14}{4}$
   h. $\frac{31}{4}$
   i. $\frac{29}{3}$
   j. $\frac{17}{3}$

2. a. $3\frac{1}{5}$
   b. $2\frac{2}{5}$
   c. $5\frac{2}{3}$
   d. $2\frac{2}{3}$
   e. $4\frac{1}{2}$
   f. $1\frac{6}{13}$
   g. $1\frac{1}{7}$
   h. $2\frac{11}{32}$
   i. $1\frac{7}{17}$
   j. $1\frac{4}{9}$

Part B

1. $\frac{1}{3}$
2. $\frac{1}{3}$
3. $\frac{2}{3}$
4. $\frac{3}{5}$
5. $\frac{1}{4}$
6. 1
7. $\frac{2}{3}$
8. $\frac{1}{3}$
9. $\frac{1}{2}$
10. $\frac{5}{6}$

Part C

1. a. 9
   b. $\frac{6}{9}$
   c. $\frac{7}{9}$

Answers to Student Supplement 1

2. a. 24
   b. $\frac{21}{24}$
   c. $\frac{20}{24}$

3. a. 24
   b. $\frac{8}{24}$
   c. $\frac{22}{24}$
   d. $\frac{9}{24}$

4. a. 56
   b. $\frac{8}{56}$
   c. $\frac{35}{56}$

5. a. 16
   b. $\frac{1}{16}$
   c. $\frac{6}{16}$
   d. $\frac{12}{16}$

Part D

1. $1\frac{5}{24}$
2. $1\frac{4}{15}$
3. $1\frac{3}{16}$
4. $2\frac{2}{5}$
5. $\frac{5}{24}$
6. $\frac{17}{40}$
7. $\frac{13}{72}$
8. $\frac{1}{48}$
9. $3\frac{3}{8}$
10. $3\frac{1}{4}$

Answers to Student Supplement 1

11. $\frac{7}{12}$
12. $\frac{1}{24}$
13. $\frac{3}{4}$
14. $13\frac{1}{3}$
15. $8\frac{1}{4}$

Part E

1. 5.6
2. 1.02
3. .087
4. 7.083
5. 5.06
6. 3.75
7. 55.5
8. 110.625
9. 77.02
10. 12.667

Part F

1. 19.29
2. 180.99
3. 351.98
4. $2.47
5. 7.874
6. 297.5
7. 39.6
8. 100.32
9. 153
10. 1.5

Part G

1. 25%
2. 22.2%
3. 70%
4. 75%
5. 100%

Part H

1. 25%
2. 89%
3. 12
4. 1
5. $96.00

Part I

1. 135 cu. yd. of sand
2. 225 cu. yd. of 1/4" aggregate
3. 100 gal. of solvent
4. 1 qt. of oil
5. 0.9 gal. cleaner

Answers to Student Supplement 1

Part J

1.

	RATIO (FEET)	RATIO (INCHES)	SLOPE RATIO
a.	24:12	--	2:1
b.	--	15:5	3:1
c.	5:0.05	60:0.6	100:1
d.	3:0.08	36:1	36:1
e.	12:0.33	144:4	36:1

2. a. 8 ft.
   b. 16 in.

3. a. 12.5 ft.
   b. 4 ft.
   c. 160 ft.

Part K

1. a. 4 ft.
   b. 104 yd.
   c. 216 cu. ft.
   d. 63 sq. ft.
   e. 44 qt.

2. a. 432 sq. ft.
   b. 390 sq. in.
   c. 14 cu. ft.
   d. 432 cu. in.
   e. 4 cu. in.

3. a. 12.8 tons
   b. 4 sq. ft.
   c. 28 cu. ft.
   d. 1120 sq. ft., 3.2 gal. of paint

Part L

1. a. 90°
   b. 10°
   c. 145°

2. a. 41°
   b. 46°
   c. 66°
   d. 50°
   e. 64°
   f. 78°

3. a. 100°
   b. 17°
   c. 63°
   d. 63°
   e. 17°

4. a. 52°
   b. 128°
   c. 52°
   d. 142°

5. a. 50°
   b. 97°
   c. 83°
   d. 47°
   e. 40°
   f. 83°
   g. 7°
   h. 43°

Written Test

Name ____________________

Date ____________________ Score __________

Objective 1

Match the terms related to civil technology applications with their definitions. Definitions continue on the next page.

1. Bathymetric map
2. CAD
3. CAM
4. Cartography
5. Chart
6. Civil drafting technician
7. Civil engineer
8. Civil engineering
9. Contour line
10. Culture
11. Elevation
12. Geodetic survey
13. Geographic
14. Hypsographic map
15. Hypsometric map
16. Isopleth map
17. Map
18. Pantograph
19. Planimeter
20. Planimetry
21. Plan view
22. Profile
23. Stereoscope
24. Surveying
25. Topography
26. USGS

_____ a. Features on a map that are constructed by man

_____ b. A person who supports civil engineering with the preparation of technical materials, participates as a member of a design team, and acts as a link between field work and final map preparation

_____ c. Map delineating the form of the bottom of a body of water by using depth contours

_____ d. Signifying basic relationship to the earth considered as a globe-shaped body; applies to data based on the geoid and on the spheroid

_____ e. The science of making maps and charts

_____ f. A discipline concerned with the design and construction of various municipal and state projects for the general public, such as bridges, roads, dams, canals, pipelines, and drainage

_____ g. A precise survey of considerable extent which takes into account the shape of the earth

_____ h. Computer-aided drafting or design

_____ i. Altitude or height above sea level

_____ j. Special-purpose map designed for navigation or to present specific data or information; chiefly used for nautical and aeronautical navigation

_____ k. A person who has completed a minimum of four years of college and has specialized in civil-related engineering

_____ l. Computer-aided mapping

_____ m. A line used to connect points on a land surface that have the same elevation

_____ n. A view as seen from directly above the land

_____ o. Map consisting of lines connecting places of equal value of distribution for a given theme such as rainfalls or temperature

_____ p. The configuration or shape of the land surface of any area

_____ q. Map showing relief with elevations referred to the national geodetic vertical datum of 1929

_____ r. Determining and representing accurately on paper the area of any portion of the earth's surface, the lengths and directions of the boundary lines, and the contour of the surface by taking linear and angular measurements, and by applying the principles of geometry and trigonometry

_____ s. An instrument for copying maps and drawings at a predetermined reduction or enlargement

_____ t. United States Geological Survey

_____ u. Map showing relief of any convention, such as contours, hachures, shading, or tinting

_____ v. Graphic representation of the earth's surface drawn to scale on a plane surface

_____ w. An outline of a cross section of the earth

_____ x. A device for measuring small areas by mechanical integration

_____ y. An optical instrument used for viewing two properly related photographs or diagrams simultaneously to obtain the impression of a 3-dimensional object

_____ z. Plan detail of a map

Objective 2

Select from the following list the required skills of a civil technician by placing an "X" in the appropriate blanks.

_____ a. CAD training: CAM and GIS

_____ b. Computer programming training

_____ c. Science skills up through physics

_____ d. Recognition of map symbols and abbreviations

_____ e. Basic drafting techniques in line work, lettering, and the use of tools and equipment

_____ f. Math skills up through trigonometry

_____ g. Public speaking skills

_____ h. Good communication skills

_____ i. Understanding of data automation and maintenance

_____ j. Surveying skills

Objective 3

List four job responsibilities of a civil technician.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Objective 4

List three major employment opportunities for a civil technician.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 5

Distinguish between organization structures for design teams in small and large firms by placing an "X" next to the descriptions of small firms.

_____ a. Communication is usually by word of mouth

_____ b. Usually have an organizational/standards manual which will include personnel policies and technical procedures

_____ c. Have specific lines of authority and responsibility

_____ d. The technician will have many different job responsibilities

_____ e. Are able to specialize in a specific area

_____ f. Usually have ten or fewer staff members

_____ g. Are less structured

Written Test

Objective 6

List seven specialty areas for civil engineering firms.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

Objective 7

Select from the following list the occupations related to civil drafting by placing an "X" in the appropriate blanks. Select only those that a civil technician would be able to move into with minimal extra training.

______ a. CAM/CAD technician

______ b. Data base manager

______ c. Map maker

______ d. Surveyor

______ e. Topographic technician

______ f. Pipe drafter

______ g. Civil engineer

______ h. City engineer

______ i. Civil engineering technician

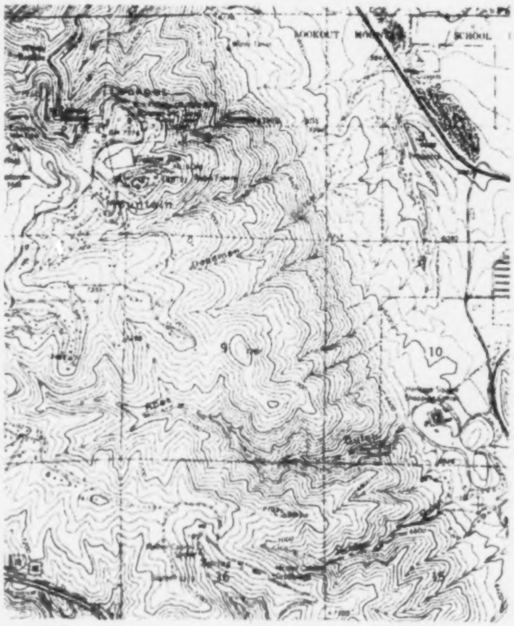
______ j. Construction materials testing technician

______ k. Electronic drafter

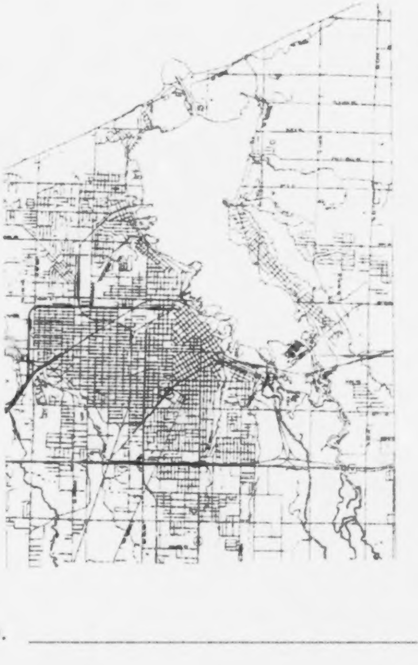
______ l. Traffic technician

Objective 8

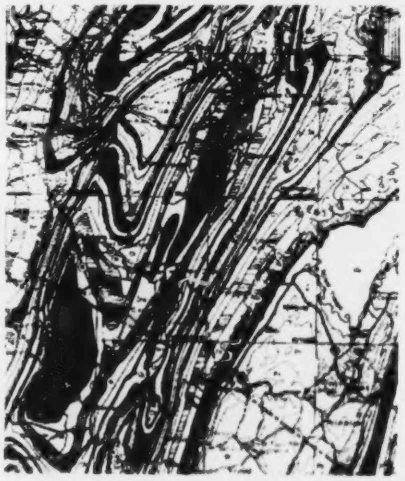
Identify the following major types of maps. Write your answers in the blanks provided.



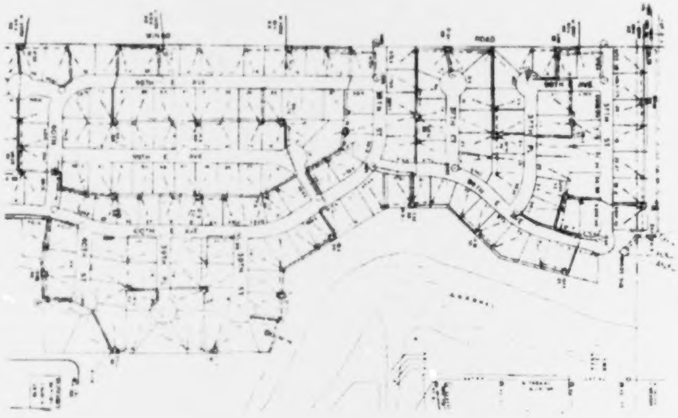
a. ______________________________



b. ______________________________



c. ______________________________



d. ______________________________

Objective 9

Match major types of maps with their characteristics.

Note: Types of maps may be used more than once.

1. Aeronautical charts
2. Cadastral maps
3. Engineering maps
4. Geographic maps
5. Hydrographic charts
6. Topographic maps

_____ a. Are used primarily for showing political and civil boundaries, property lines, taxation, and transfer of property; are considered legal documents

_____ b. Use contour lines to show elevation; represent surface features of a region; large scale maps show all the natural features down to small streams and man-made features such as city streets, bridges, pipelines, etc.

_____ c. Show shorelines, water depths, information about harbors, anchorage details, and shipping approaches

_____ d. Show large area of land; are drawn to a small scale; only show major features such as rivers, lakes, and dots for cities

_____ e. Examples are maps for railroad, highway, canal, and hydroelectric construction, building site maps, landscape maps, and dam and reservoir maps

_____ f. USGS maps in this class are always bounded by meridians of longitude and latitude

_____ g. Are drawn for reconnaissance, construction, or maintenance purposes; can show more detail than topographic maps since they are larger in scale

_____ h. Show air traffic routes, radio and electronic aids, obstructions, and elevations of high points

_____ i. Examples include plats of city additions, mineral rights, and farm surveys

Objective 10

Match typical drawings used in civil drawing with their correct uses.

1. Intersection details
2. Plan and profile
3. Pictorial drawings
4. Schematic diagrams
5. Structural details
6. Title sheets (key maps)
7. Typical cross sections

_____ a. Provide the viewer a three-dimensional view of the map area

_____ b. Are views of the inside of the project cut open at right angles to the survey centerline

_____ c. Are drawings composed of a plan view and profile view

_____ d. Identify the project with a name and number, show location map of the project, and give an index to all sheets in the plan set

_____ e. Are enlarged drawings of an intersection of several streets that come together; show all pertinent information such as dimensions, right-of-ways, centerlines, and curve data

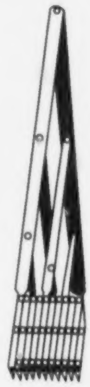
_____ f. Are details that may show connections and flow directions through the use of symbols, lines, and dimensions

_____ g. Provide a close-up look at how a particular structural component is made; shows materials, dimensions, and section where needed

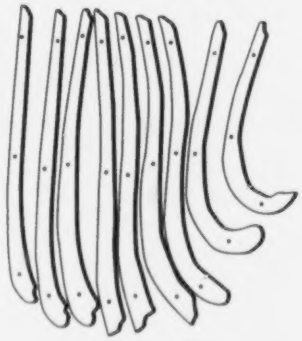
Written Test

Objective 11

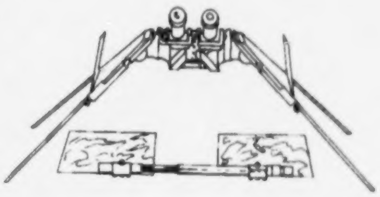
Identify the following drafting equipment used by civil technicians. Write your answers in the blanks provided.



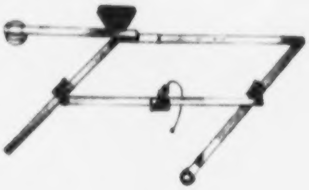
a. ____________________



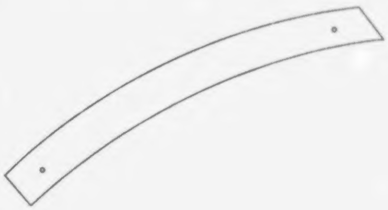
b. ____________________



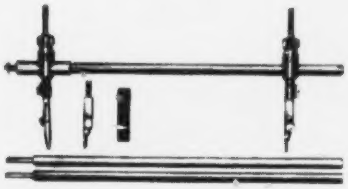
c. ____________________



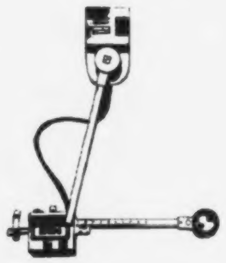
d. ____________________



e. ____________________



f. ____________________



g. ____________________

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a.	10	h.	2	o.	16	v.	17
b.	6	i.	11	p.	25	w.	22
c.	1	j.	5	q.	14	x.	19
d.	13	k.	7	r.	24	y.	23
e.	4	l.	3	s.	18	z.	20
f.	8	m.	9	t.	26		
g.	12	n.	21	u.	15		

Objective 2

a, d, e, f, h, i

Objective 3

Any four of the following:

a. Prepare maps and plans
b. Work with survey data
c. Gather, organize, record, and enter data (data base manager)
d. Perform engineering calculations
e. Manage a computer CAD system (systems manager)
f. Compile map data and map production
g. Operate a CAM program
h. Develop CAD software programs
i. Assist in the drafting and design of:
    - Subdivisions
    - Surface drainage systems
    - Major structures
    - Water treatment facilities
    - Water distribution facilities
    - Storm sewer systems
    - Transportation systems
    - Utility facilities
    - Structural plans
    - Site plans

j. Communicate effectively

Objective 4

Any four of the following:

a. Private civil engineering and surveying firms
b. Local government agencies
    - County planning office
    - City planning department
    - Highway department
    - Water department
    - Engineering and planning office
    - Parks and recreation department

c. Federal government agencies
    - Department of Transportation
    - Bureau of Census
    - Defense Mapping Agency (DMA)

Answers to Written Test

- Department of the Interior
- Department of Agriculture
- Bureau of Indian Affairs
- All energy regulatory agencies
- Corps of Engineers
- Soil Conservation
- Department of Commerce

Objective 5

a, d, f, g

Objective 6

Any seven of the following:

a. Land planning and subdivision
b. Transportation
c. Flood control
d. Irrigation and drainage
e. Sewage and water treatment
f. Municipal improvements
g. Environmental studies
h. Land and conservation surveys
i. Construction inspection
j. Refuse disposal
k. Map making
l. Power plants
m. Graphic information systems (GIS)
n. Hydrologic studies
o. Foundation work and soil analysis
p. Agribusiness
q. Structural

Objective 7

a, b, c, e, i, j, l

Objective 8

a. Topographic
b. Base map
c. Land use map
d. Cadastral

Objective 9

a. 2
b. 6
c. 5
d. 4
e. 3
f. 6
g. 3
h. 1
i. 2

Objective 10

a. 3
b. 7
c. 2
d. 6
e. 1
f. 4
g. 5

Objective 11

a. Spacing dividers
b. Ship curves
c. Stereoscope
d. Pantograph
e. Highway radius curves
f. Beam compass
g. Electronic planimeter

Unit 1

Introduction to Civil Technology Applications

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Student Supplement 1, "Math Assessment."

☐ 4. **Stop** Ask instructor to evaluate the completed math assessment. After work has been evaluated, follow instructor's recommendations.

☐ 5. **Study** Information Sheet, Objectives 1 through 3.

☐ 6. **Do** Assignment Sheet 1, "Interview a Civil Technician."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, meet with instructor to determine needed improvements.

☐ 8. **Study** Information Sheet, Objectives 4 through 7.

☐ 9. **Do** Assignment Sheet 2, "Research Possible Employment Opportunities in Civil Drafting Technology in Your Local Area."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, meet with instructor to determine needed improvements.

☐ 11. **Study** Information Sheet, Objectives 8 through 11, and Student Supplements 2 through 4.

Learning Activities Sheet

☐ 12. Go — To computer and complete Assignment Sheet 3, "Access the Internet for Mapping Resources."

☐ 13. Stop — Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, meet with instructor to determine needed improvements.

☐ 14. **Check** — With instructor for any additional assignments to be completed.

☐ 15. **Do** — Additional assignments listed below.

☐ 16. **Take** — Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 17. **Stop** — Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Teacher Supplement 1—Free Earth Science Publications (Factsheets)

Aerial Photography Summary Record System—Describes the data base that locates aerial photography projects and gives source information. (Feb. '92)

Careers in Cartography at the U.S. Geological Survey—Describes positions in cartography at the USGS, including qualifications, salaries, and benefits. (Apr. '93)

Cartographic Applications Software—Describes computer software developed by USGS in the fields of surveying, geodesy, remote sensing, and photogrammetry. (Nov. '93)

Cartographic Data on CD-ROM—Describes various cartographic data available to the public on CD-ROM. (Dec. '94)

Commemorative Naming in the United States—Provides information on national geographic name standardization, policy, guidelines, and procedures for submitting name proposals for commemorative naming. (Sept. '95)

Declassified Intelligence Satellite Photographs—Explains how to obtain declassified satellite photographs collected by the U.S. Intelligence Community during the 1960's. (Feb. '96)

Digital Line Graph-Enhanced—Describes latest upgrades of digital line graphs. (Mar. '94)

Digital Line Graphs from U.S. Forest Service Digital Data—Gives information on digital line graphs derived from U.S. Forest Service (USFS) digital cartographic data that are available for selected quadrangles containing lands administered by the USFS. (Mar '93)

Digital Orthophotos—Describes the production of USGS digital orthophotos. (Apr. '95)

Digital Raster Graphics—Provides information about digital raster graphics (DRG), including the production of DRG's and their various uses. Also gives ordering information. (Feb. '96)

Display Images—Lists satellite and high-altitude images of selected States, landforms, natural phenomena, and regions of the world. (Feb. '92)

Earth Science Information From the U.S. Geological Survey—Lists major sources of information about the Nation's mineral, land, and water resources. (Apr. '96)

Earth Science Publications–Booklets, Leaflets, and Posters—Describes these publications available at no charge from the USGS and gives ordering information. (Mar. '93)

Earth Science Publications–Fact Sheets—Describes these publications available at no charge from the USGS and gives ordering information. (Apr. '96)

Ecological Inventory Maps—Lists, describes, and gives ordering information for ecological inventory maps produced by the U.S. Fish and Wildlife Service. (Sept. '91)

Explanation of APSRS Printout—Lists items that may be included in the computer printout records of aerial photography projects provided to the USGS by other agencies. (Oct. '92)

Geographic Names Information System—Describes the three data bases on names information for known places, features, and areas in the 50 States, the District of Columbia, and the territories and outlying areas of the United States that are identified by proper names. (Aug. '95)

Global Land Information System—Describes the three interfaces on which this online, interactive system is available for obtaining information about the Earth's land surface. (Apr. '96)

How to Obtain Aerial Photographs—Provides a checklist on locating and ordering aerial photographs of the United States and its territories from an informational data base of aerial photographic coverage maintained by the USGS. (Apr. '96)

How to Select and Order NAPP and NHAP Photographs—Gives step-by-step instructions on selecting and ordering National Aerial Photography Program and National High Altitude Photography Program photographs using flight-line microfiche indexes. (Sept. '92)

Land Use and Land Cover and Associated Maps—Explains the USGS land use and land cover classification system and the associated map coverage and gives ordering instructions. (May '93)

Land Use and Land Cover Digital Data—Describes USGS digital data derived from land use and land cover and associated maps and the formats in which these data are available. (Oct. '94)

Looking for an Old Aerial Photograph—Lists sources for obtaining historical aerial photographs. (July '92)

Looking for an Old Map—Lists sources for obtaining historical maps of the United States. (Mar '92)

Map Accuracy—Describes how the USGS maintains map accuracy. ('89)

Mapping Research in Antarctica—Describes USGS mapping research programs in Antarctica. (Jan. '91)

Map Projection Publications—Describes nine publications about map projections. (Aug. '94)

Map Scales—Explains map scales and includes a table showing information about USGS topographic maps. (Oct. '93)

Teacher Supplement 1

National Atlas Maps—Lists maps available for purchase from the out-of-stock publication "National Atlas of the United States." (Jan. '96)

National Gazetteer, The—Describes "The National Gazetteer of the United States of America"—a geographic dictionary of place-names. Gives prices and ordering information. (May '92)

National Uranium Resource Evaluation Data—Describes the National Uranium Resource Evaluation Program and the types of data available for earth science research. (Sept. '85)

National Wetlands Inventory Products—Describes Fish and Wildlife Service (FWS) maps of America's wetlands and lists sources of information available from the USGS and the FWS. (Dec. '95)

NHAP and NAPP Photographic Enlargements—Gives enlargement sizes. (Apr. '96)

1:100,000-Scale Digital Line Graph Hydrography and Transportation Data on CD-ROM—Provides information on the series of CD-ROMs produced by the USGS, the price, hardware requirements, and ordering information. (Jan. '96)

1:2,000,000-Scale Digital Line Graph Data on CD-ROM—Describes the two digital line graph data CD-ROMs that are now available from the USGS, including the data content and organization, software and hardware information, and ordering information. (July '95)

Orthophoto Products—Describes USGS orthophoto products, including their availability and cost, and gives ordering information. (Aug. '91)

Out-of-Print Maps—Explains how to obtain a paper reproduction or microfilm copy of an out-of-print USGS map. (Feb. '96)

Revision and Product Generation Software—Provides information on software used for updating digital line graph data and producing maps from such data, including its primary capabilities and the system requirements. (Mar. '95)

SCAR Library—Describes the Nation's major library of Antarctic aerial photographs, maps, charts, and satellite images. (May '90)

The Scientific Assessment and Strategy Team (SAST)—The SAST provides scientific advice and assistance for flood recovery and river basin management in the Upper Mississippi River Basin. (Apr. '96)

Side-Looking Airborne Radar (SLAR)—Describes images available for geologic analysis, petroleum and mineral exploration, land use mapping, and ground water studies, and provides an index of SLAR images. (May '92)

Spatial Data Transfer Standard (SDTS)—Describes the standards adopted for all Federal agencies, USGS support in implementing these standards, and sources of information. (Aug. '95)

The Universal Transverse Mercator (UTM) Grid—Explains the UTM grid origin and how to determine a UTM grid value for a map point. (May '93)

US GeoData Available through the Internet—Lists select US GeoData data bases offered by the USGS, describes access and formats for the data files, and gives ordering information. (Feb. '96)

US GeoData Digital Elevation Models—Provides information about USGS digital elevation model data and gives ordering instructions. (Apr. '96)

US GeoData Digital Line Graphs—Describes digital line graph data available from the USGS and gives ordering instructions. (Apr. '96)

US GeoData Sampler—Describes a sample file of cartographic and geographic data produced by the USGS. (July '92)

USGS Node of the National Geospatial Data Clearinghouse—Lists the data sets currently available in electronic form through the USGS node of the National Geospatial Data Clearinghouse. (Jan. '95)

USGS Scientific Visualization Laboratory—The lab provides a central facility where USGS employees can use state-of-the-art equipment for products ranging from presentation graphics to complex visual representations of scientific data. (Apr. '95)

USGS World Wide Web—Lists web sites to explore an earth science library of digital information, publications, and data.

U.S. Map Indexes—Describes maps and map series, digital cartographic data, thematic maps, and aerial photographs available from the USGS. (Sept. '95)

What's Under Your Feet?—Describes an earth science booklet of the same name published by USGS for use by elementary schools. (June '92)

INFORMATION

Single copies of these publications are available free at any U.S. Geological Survey (USGS) Earth Science Information Center (ESIC). Additional copies (50 maximum) can be ordered from:

USGS Information Services
Box 25286
Denver, CO 80225

For information on these and other USGS products and services, call

1-800-USA-MAPS, fax 703-648-5548, or e-mail: esicmail@usgs.gov

The EARTHFAX fax-on-demand system is available 24 hours a day at 703-648-4888.

The USGS home page address is: <URL: http://www.usgs.gov/>

Teacher Supplement 2—U.S. Geological Survey List of Products, Information and Special Services

- Aerial Photography
- Certification of USGS Documents
- Coastal Barrier Maps
- Color Feature Separates
- Computer Software
- Coordinate Reader Templates
- Data Users Guides
- Digital Data
- Geographic Names and Information System (GNIS) Products
- National Uranium Resource Evaluation (NURE)
- National Wetlands Inventory Maps
- Open File Reports
- Orthophotoquads
- Out-of-Print Topographic Maps (Historical Editions)
- Satellite Data
- Technical Standards
- Water Resource Investigations (WRI)

The above products can be obtained by contacting:
U.S. Geological Survey
Box 25046, Mailstop 504
Denver, CO 80225
(303)202-4200

- Books
- Bulletins
- Circulars
- General Interest Publications (GIPS)
- Professional Papers
- Published Maps (Topographic, Thematic, Geologic)
- Teacher's Packets
- Techniques of Water Resources Investigations Series (TWRI)
- Selected Defense Mapping Agency (DMA) Products
- Water Supply Papers

These products can be obtained by contacting:
U.S. Geological Survey
Box 25286, Mailstop 306
Denver, CO 80225
(303)202-4700

Horizontal and Vertical Control Lists (Benchmarks)

The above products can be obtained by contacting:
U.S. Geological Survey
Box 25046, Mailstop 518
Denver, CO 80225
(303)202-4400

Teacher Supplement 2

Geomagnetism—Current and historical geomagnetic field information for the U.S. and the world, secular change information, charts, observatory digital data, magnetic storms.

The above information can be obtained by contacting:
National Geomagnetic Information Center
U.S. Geological Survey
Box 25046, Mailstop 968
Denver, CO 80225
(303) 273-8486
message machine (303) 273-8494
fax (303) 273-8506

The Geologic Inquiries Group (GIG) is the information office which acts as the primary public interface for the Geologic Division. GIG will provide or arrange for complete and specific responses to all geology-related questions from the general public, precollege and college teachers and students, businesses, government agencies, and from other information offices. GIG specialists maintain up-to-date reference lists on popular geologic subjects, citing U.S. Geological Survey (USGS) publications and those of other organizations. These subjects include:

geology and minerals of each state
prospecting
oil and gas maps of the U.S.
earthquakes and volcanoes
State geologic maps
Geologic Map Indexes (GMI) for each State
rocks, minerals and gemstones
plate tectonics
careers in the geosciences
environmental geology
....and many others

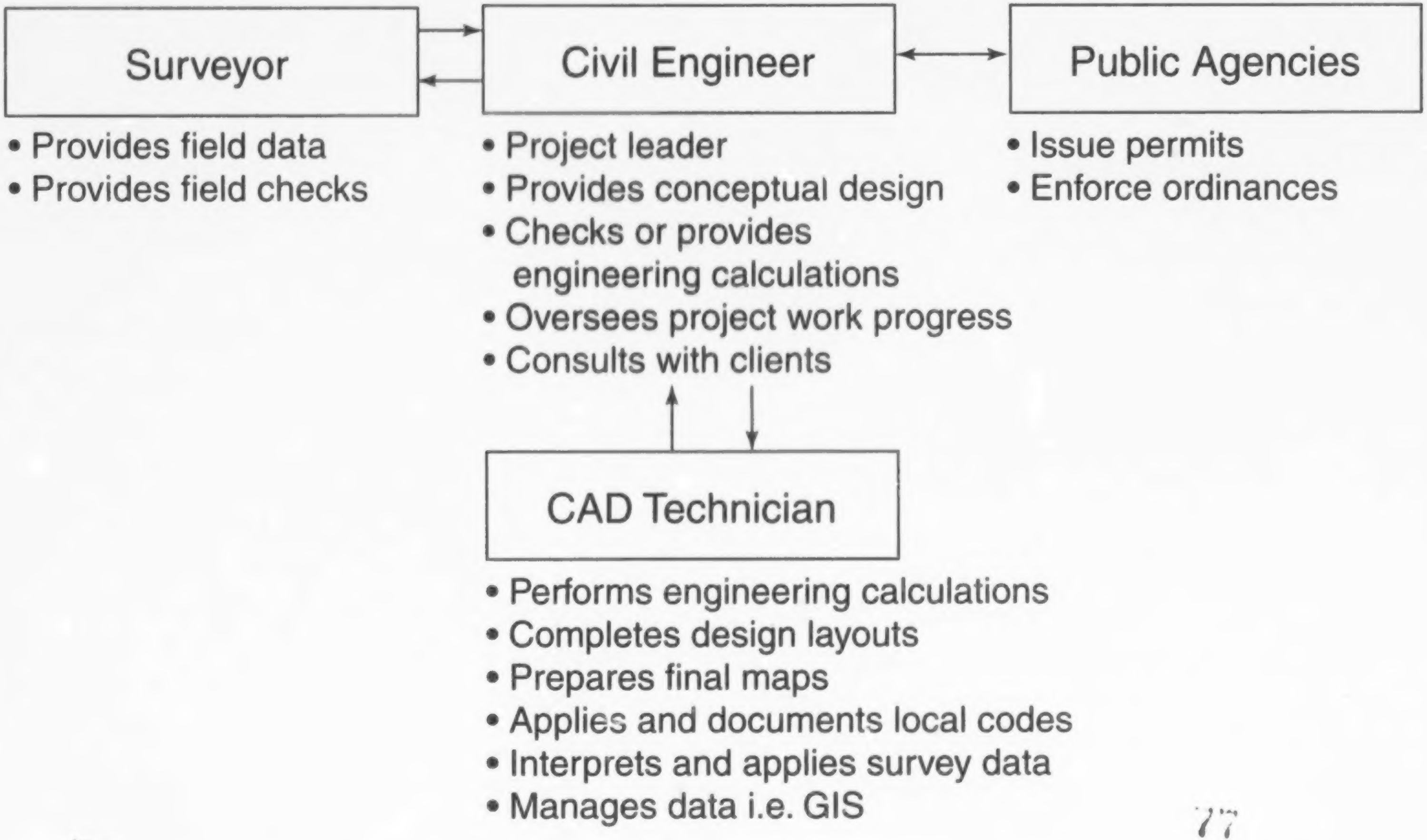
GIG also provides outreach to the education community by identifying earth science resources useful for teaching purposes, and advising teachers and curriculum developers about USGS products and services that would supplement their earth science curriculum. (e.g., U.S. Geological Survey sales publications that are especially useful to teachers; education resources available through the USGS).

To assist elementary and high school teachers GIG offers two packets of earth science teaching aids, which differ according to grade level and geographic location. The packets include lists of reference materials from various sources, and leaflets and booklets on a variety of earth science topics. The packets are free to teachers and workshop leaders who mail requests to GIG on school letterhead.

GIG maintains a file of free USGS publications such as circulars, general interest publications, and map indexes to respond to inquiries.

The above information can be obtained by contacting:
Geologic Inquiries Group
U.S. Geological Survey
Mailstop 907, National Center
Reston, VA 22092
(703) 648-4383
fax (703) 648-6645

Typical Work Flow and Job Duties (Small Office)



Surveyor

- Provides field data
- Provides field checks

Civil Engineer

- Project leader
- Provides conceptual design
- Checks or provides engineering calculations
- Oversees project work progress
- Consults with clients

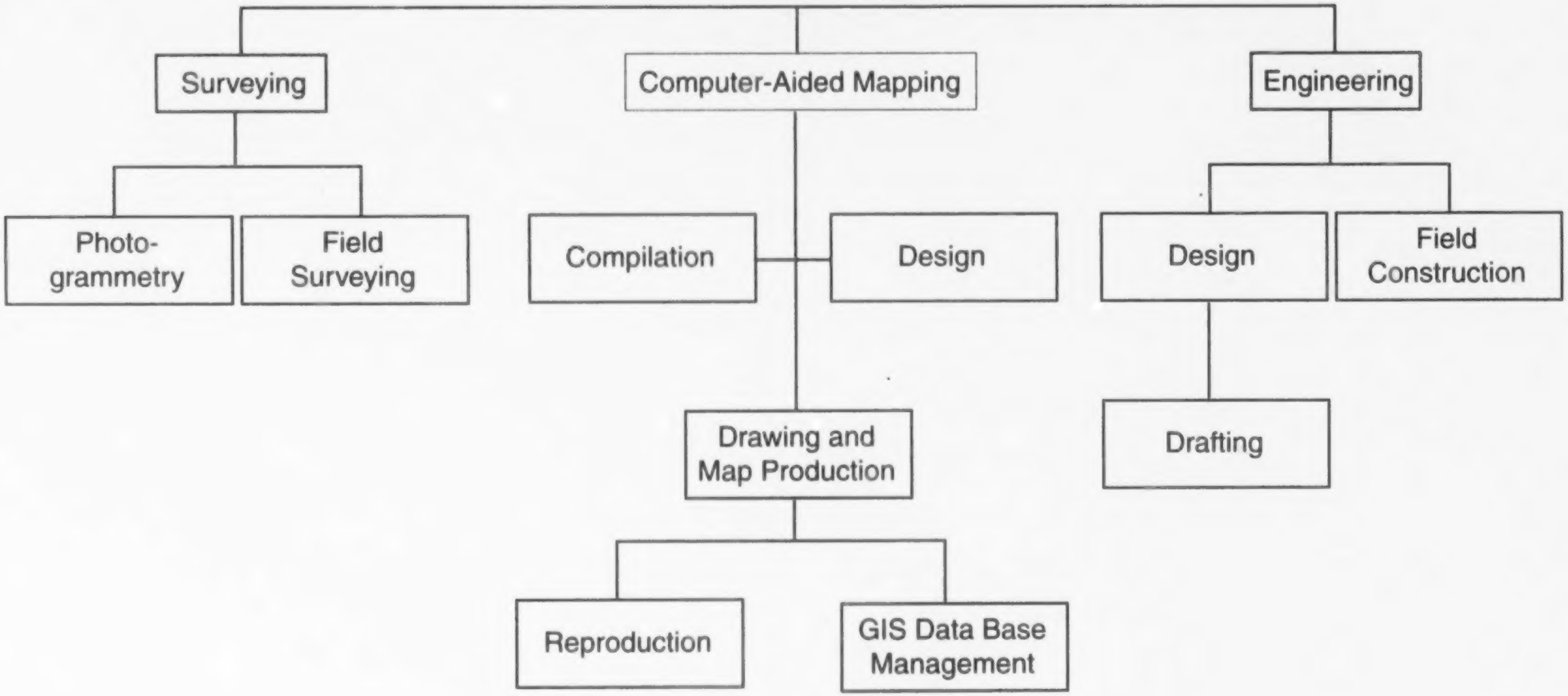
Public Agencies

- Issue permits
- Enforce ordinances

CAD Technician

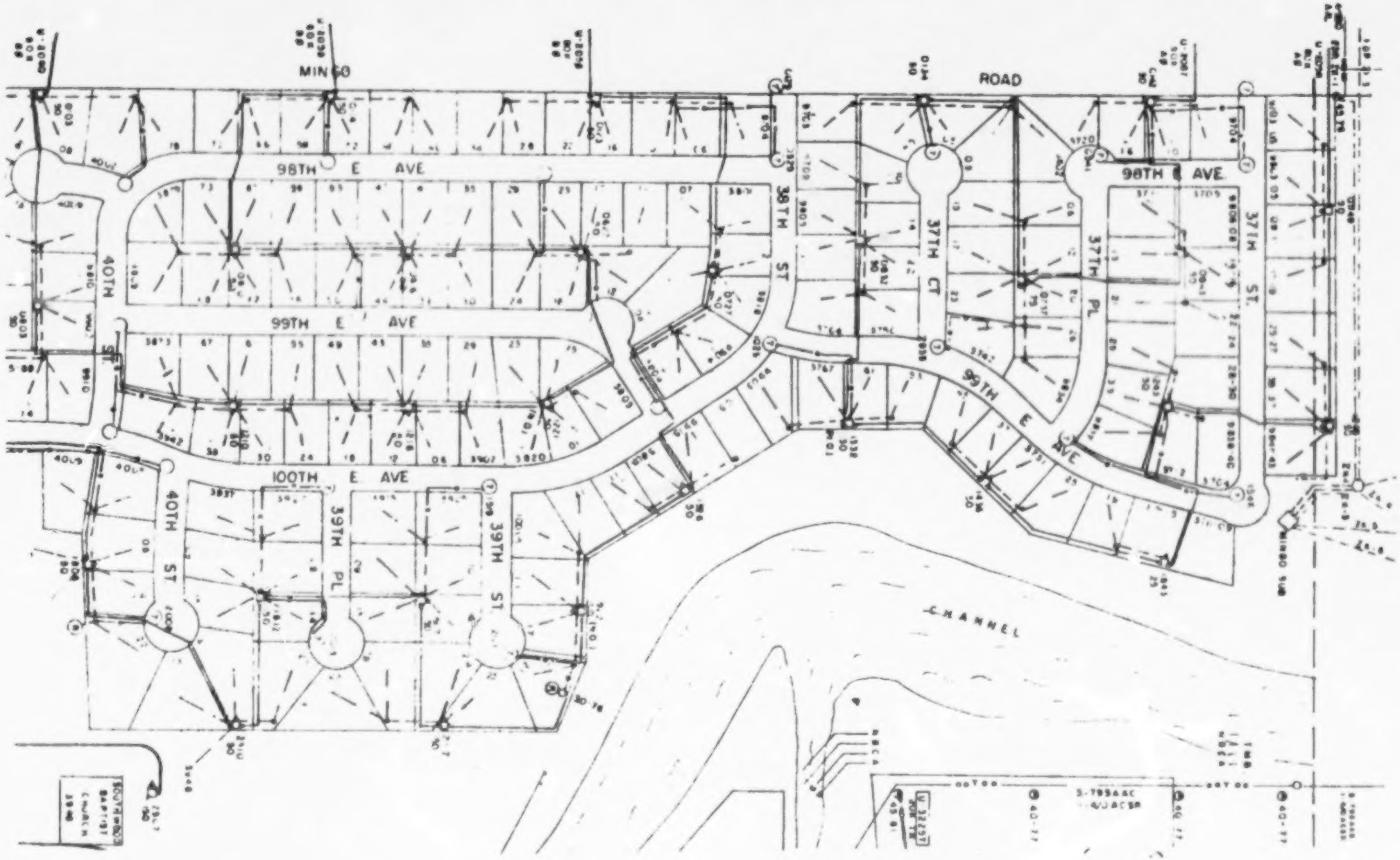
- Performs engineering calculations
- Completes design layouts
- Prepares final maps
- Applies and documents local codes
- Interprets and applies survey data
- Manages data i.e. GIS

Typical Organizational Chart (Large Civil Engineering Firm)

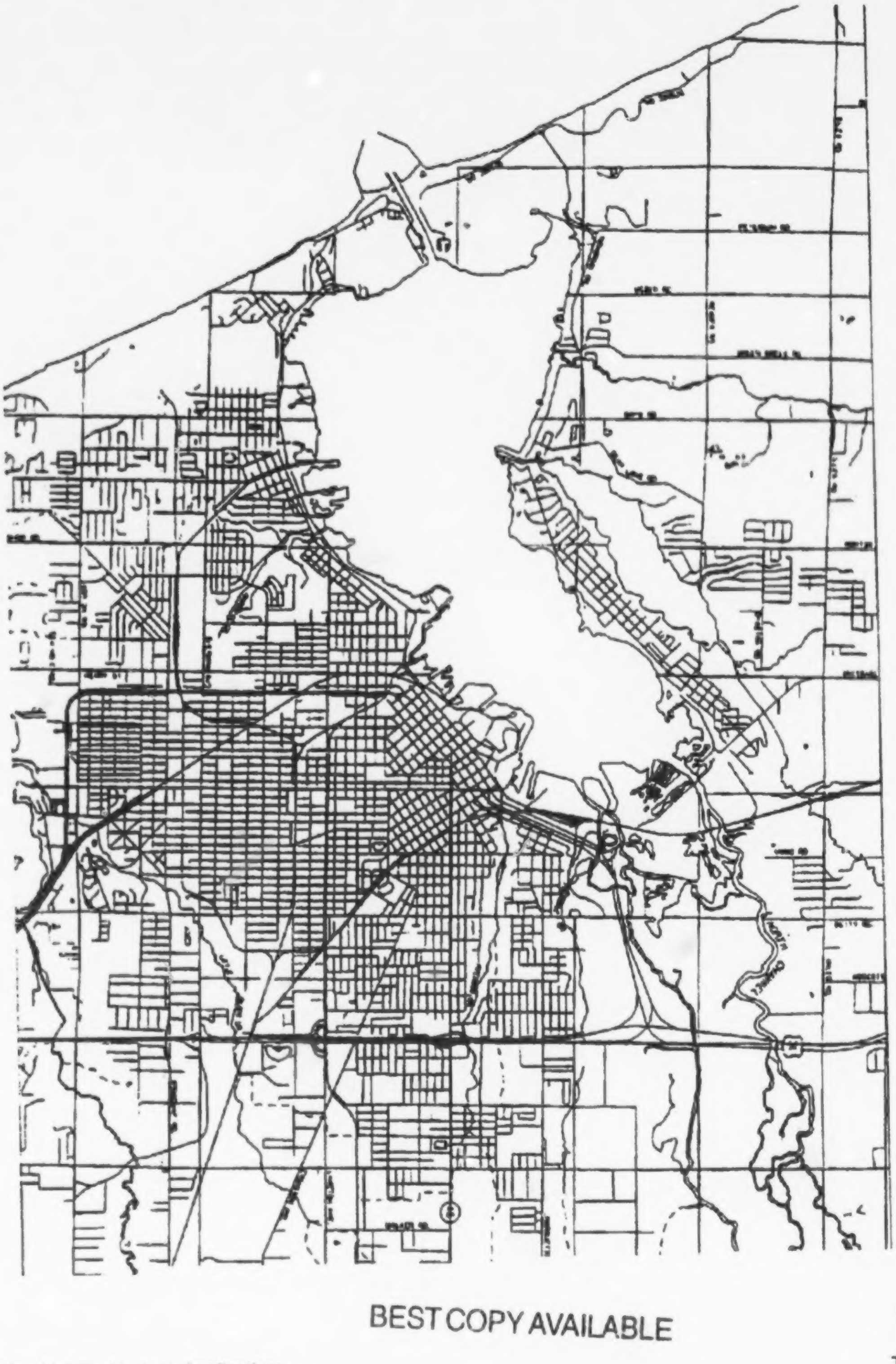


- Surveying
  - Photo-grammetry
  - Field Surveying
- Computer-Aided Mapping
  - Compilation
  - Design
  - Drawing and Map Production
    - Reproduction
    - GIS Data Base Management
- Engineering
  - Design
    - Drafting
  - Field Construction

Example of a Cadastral Map


MINGO ROAD
98TH E AVE
98TH E AVE.
99TH E AVE
99TH E AVE
100TH E AVE
40TH ST
40TH ST
39TH PL
39TH ST
38TH ST
37TH CT
37TH PL
37TH ST.
CHANNEL

Example of a Base Map



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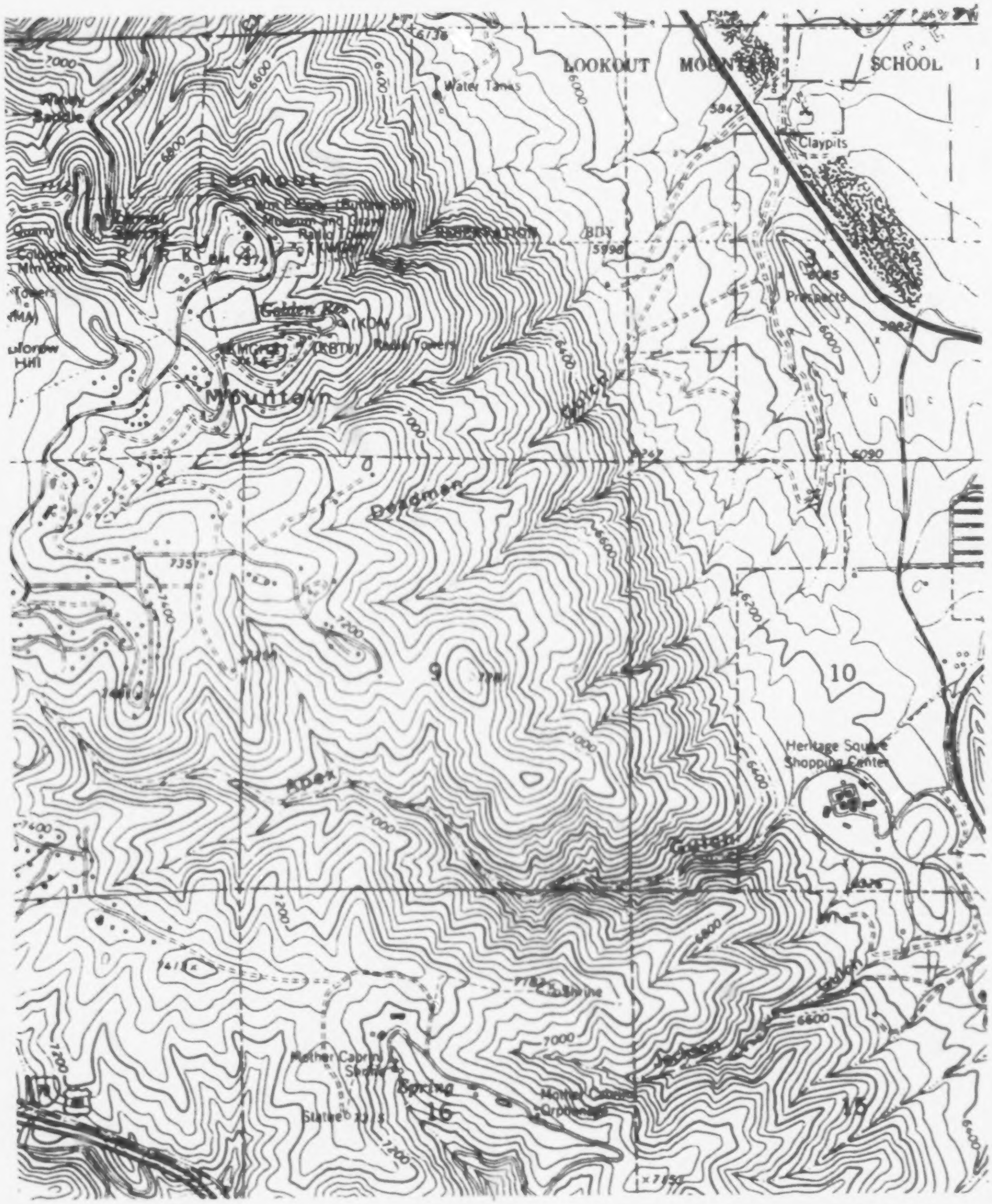
TM 4

Example of a Topographic Map


LOOKOUT
MOUNTAIN
SCHOOL
Water Tanks
Claypits
Prospects
Lookout
Mountain
Golden Res
Radio Towers
Deadman
Apex
Gulch
Heritage Square Shopping Center
Mother Cabrini Shrine
Spring
Mother Cabrini Orphanage
Jackson
9
10
16
15
6000
6200
6400
6600
6800
7000
7200
7400

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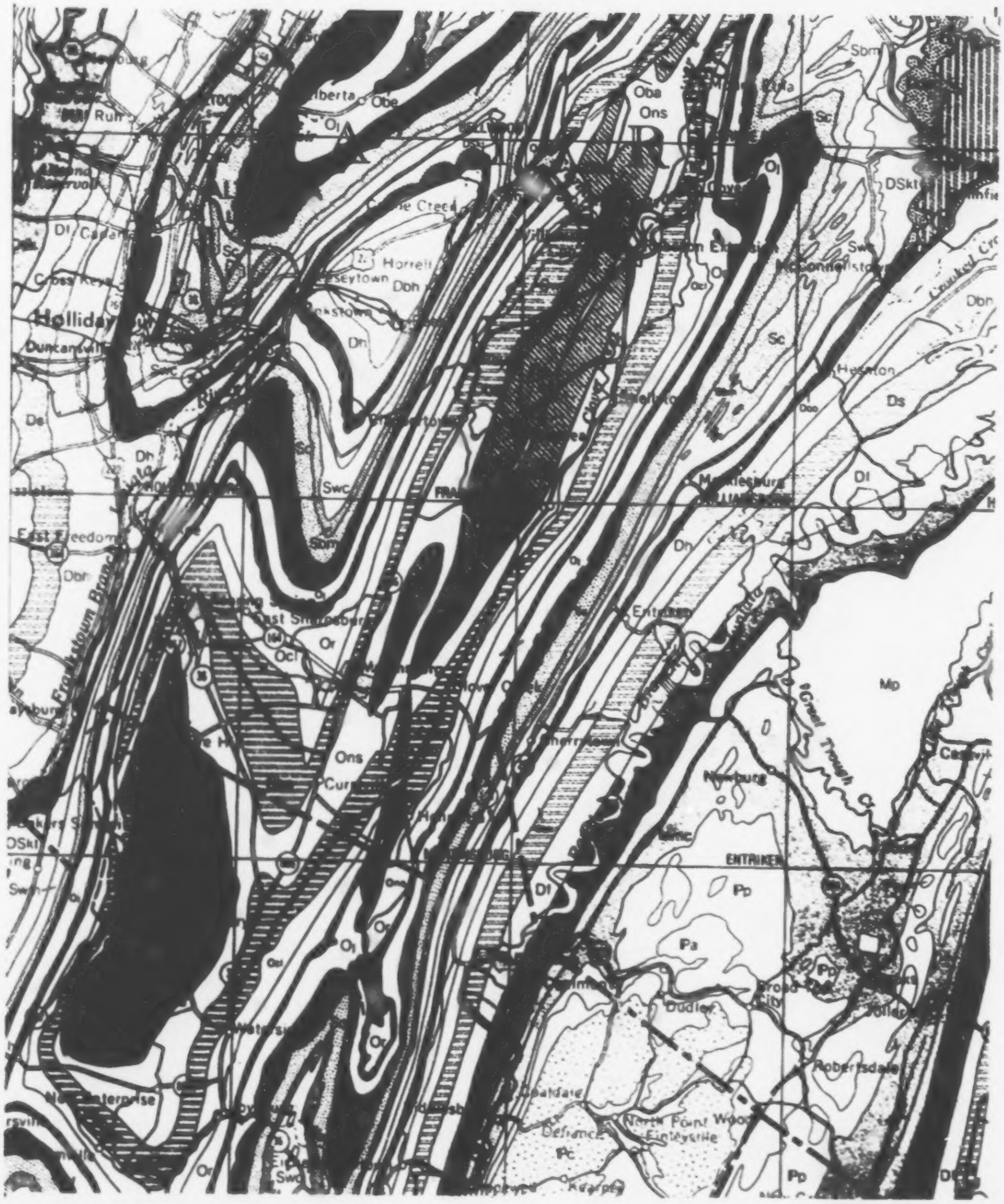
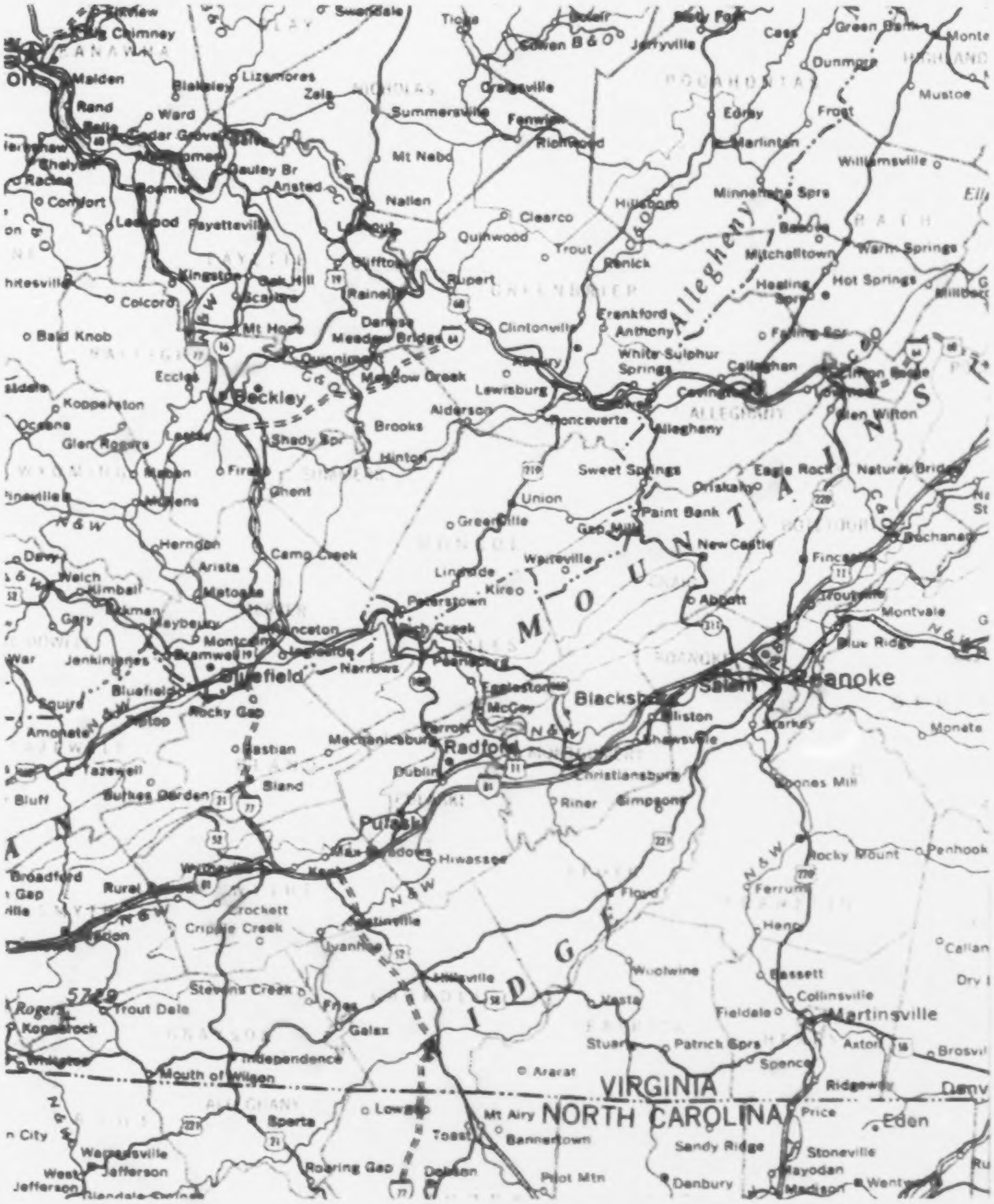
Example of a Thematic Map: Geologic Map


Sbm
Obe
Oba
Ons
Sc
Ol
DSkt
Dl
Horrell
Dbh
Duncansville
Swc
Dh
Ds
Swc
Sc
Sbm
Dbh
East Freedom
Frankstown Branch
East Sharpsburg
Or
Ocl
Ons
Crooked Creek
Dbn
Hesston
Ds
Marklesburg
Dl
Dh
Entriken
Mp
Great Trough Creek
Newburg
ENTRIKEN
Pp
Pa
Dudley
Broad Top City
Robertsdale
Coaldale
Defiance
North Point
Pc
Pp

TM 6

Example of a Geographic Map


Swandale
Tioga
Cowen B & O
Jerryville
Cass
Green Bank
Monterey
Clay Chimney
Malden
Blakeley
Lizemores
Zela
Nicholas
Craigsville
Pocahontas
Dunmore
Highland
Mustoe
Rand
Belle
Ward
Summersville
Fenwick
Richwood
Edray
Frost
Shelton
Cedar Grove
Marlinton
Williamsville
Racine
Comfort
Fauley Br
Ansted
Mt Nebo
Nallen
Hillsboro
Minnehaha Sprs
Fayetteville
Clearco
Quinwood
Trout
Allegheny
Bath
Warm Springs
Kingston
Oak Hill
Rupert
Renick
Mitchelltown
Hot Springs
Colcord
Raleigh
Scarbro
Mt Hope
Rainelle
Greenbrier
Frankford
Anthony
Bald Knob
Daniels
Meadow Bridge
Clintonville
White Sulphur Springs
Falling Spr
Eccles
Meadow Creek
Callaghan
Covington
Lewisburg
Kopperston
Beckley
Alderson
Ronceverte
Alleghany
Glen Wilton
Oceana
Glen Rogers
Shady Spr
Brooks
Hinton
Summers
Wyoming
Mullens
Fireco
Ghent
Union
Sweet Springs
Eagle Rock
Natural Bridge
Oriskany
Paint Bank
Greenville
Gap Mills
Botetourt
New Castle
Buchanan
Herndon
Camp Creek
Monroe
Waiteville
Fincastle
Davy
Welch
Kimball
Arista
Matoaka
Lindside
Kireo
Mountains
Troutville
Gary
Keystone
Maybeury
Peterstown
Abbott
Montvale
Montcalm
Princeton
Rich Creek
Roanoke
Jenkinjones
Bramwell
Bluefield
Narrows
Pearisburg
Blue Ridge
Bluefield
Eggleston
McCoy
Blacksburg
Salem
Roanoke
Squire
Rocky Gap
Elliston
Vinton
Amonate
Tiptop
Bastian
Mechanicsburg
Radford
Shawsville
Stewartsville
Tazewell
Bland
Dublin
Christiansburg
Bluff
Burkes Garden
Riner
Simpsons
Boones Mill
Pulaski
Max Meadows
Hiwassee
Rocky Mount
Penhook
Broadford
Gap
Wytheville
Rural Retreat
Crockett
Floyd
Ferrum
Cripple Creek
Ivanhoe
Austinville
Henry
Woolwine
Bassett
Callands
Marion
Hillsville
Blue Ridge
Trout Dale
Stevens Creek
Fries
Galax
Collinsville
Fieldale
Martinsville
Rogers
Konnarock
5729
Vesta
Stuart
Patrick Sprs
Axton
Brosville
Independence
Mouth of Wilson
Ararat
Spencer
Ridgeway
Danville
Virginia
North Carolina
Lowgap
Sparta
Alleghany
Mt Airy
Toast
Bannertown
Price
Eden
n City
Wagoner
Jefferson
West Jefferson
Roaring Gap
Dobson
Pilot Mtn
Sandy Ridge
Danbury
Stoneville
Mayodan
Madison
Wentworth
N & W
C & O
Blue Ridge
Ridge

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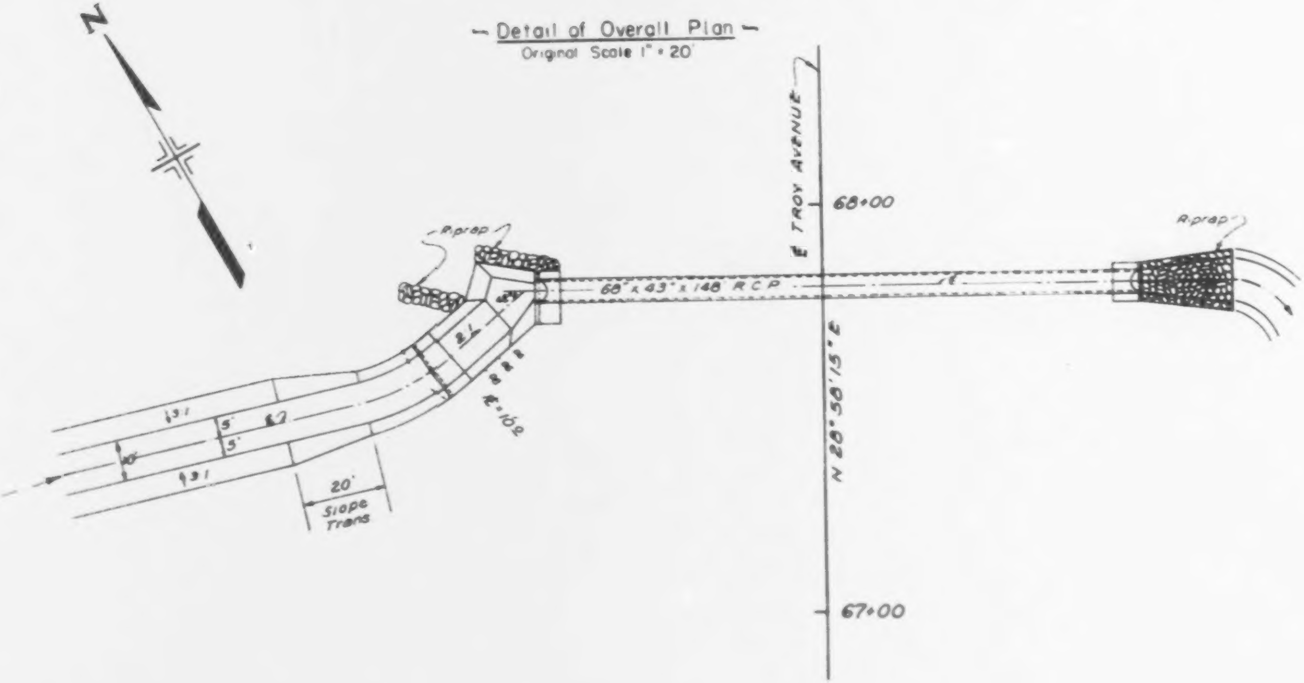
TM 7

Example of an Engineering Map

DETAIL OF DRAINAGE PLAN

TROY AVE - Sta 67 +


N
— Detail of Overall Plan —
Original Scale 1" = 20'
Riprap
Riprap
℄ TROY AVENUE
68+00
67+00
N 28°50'15" E
68" x 43" x 148' RCP
℄
3:1
3:1
5'
5'
10'
20'
Slope Trans

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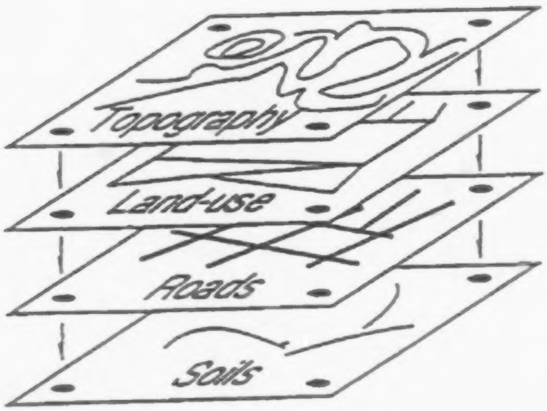
Courtesy of Colorado Department of Highways.

Example of a GIS Map



Stacked set of map layers where each layer is aligned or registered to other layers. Each layer can contain a unique graphic theme or data type such as shown in this illustration.

Reprinted from the Construction Technology Information Center's October 1994 newsletter, *Conservation Impact*.

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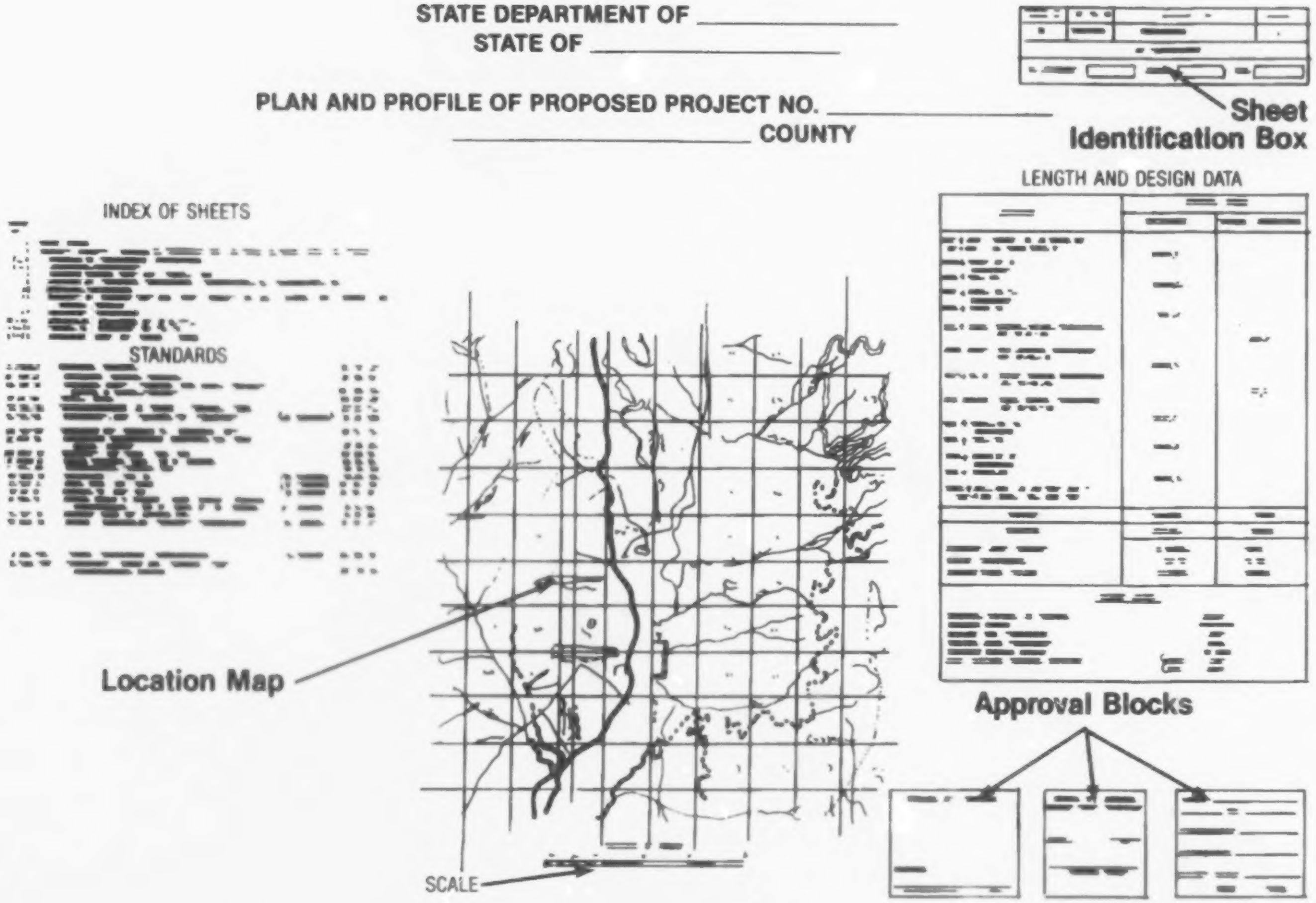
Typical Title Sheet



STATE DEPARTMENT OF ________________
STATE OF ____________________

PLAN AND PROFILE OF PROPOSED PROJECT NO. ____________________
________________________ COUNTY

Sheet Identification Box
LENGTH AND DESIGN DATA
INDEX OF SHEETS
STANDARDS
Location Map
Approval Blocks
SCALE

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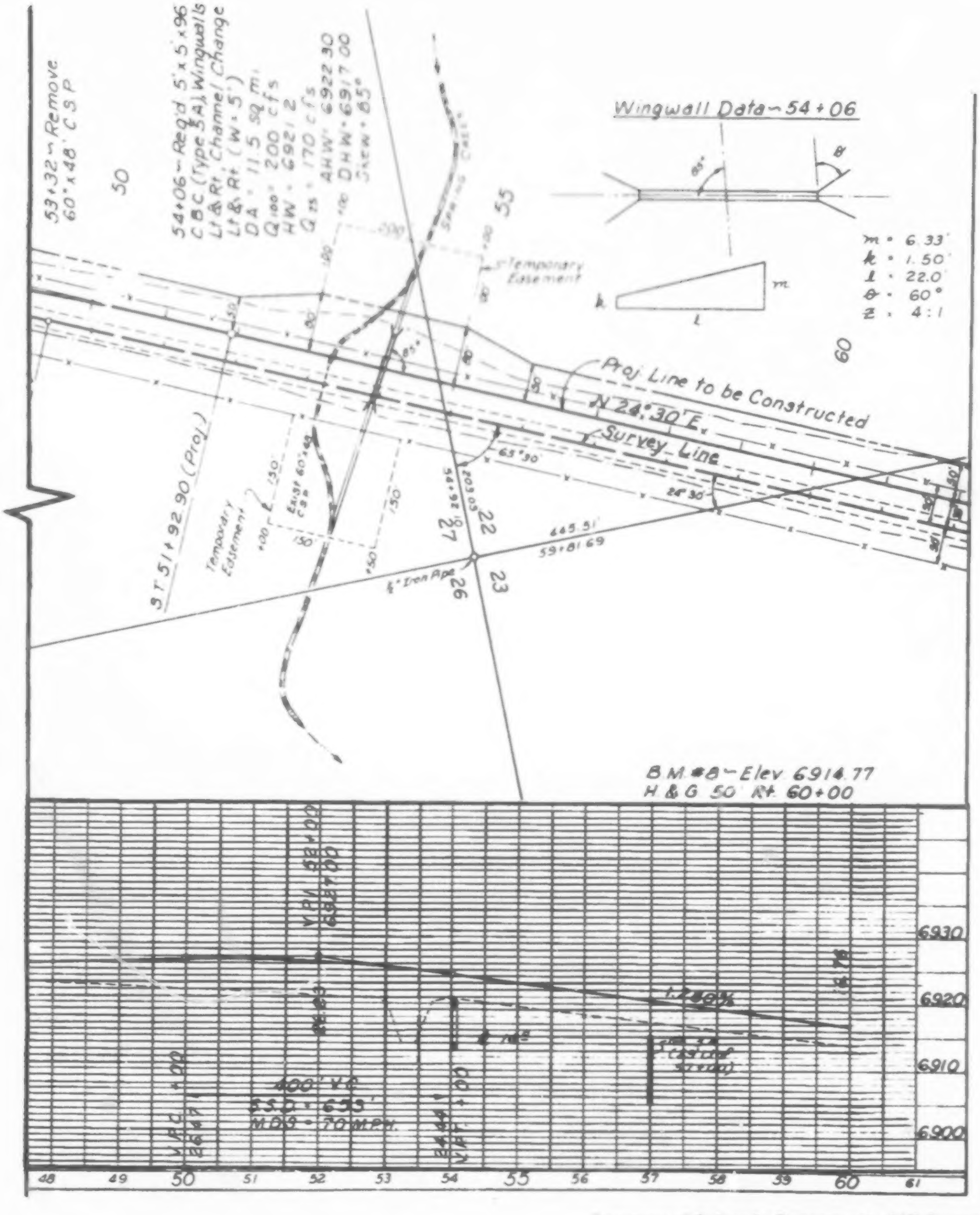
Typical Plan and Profile


53+32 ~ Remove
60" x 48" C S P
50
54+06 ~ Req'd 5' x 5' x 96
C B C (Type 5A) Wingwalls
Lt & Rt; Channel Change
Lt & Rt (W = 5')
DA = 11.5 sq mi
Q100 = 200 cfs
HW = 6921.2
Q25 = 170 cfs
AHW = 6922.30
DHW = 6917.00
Skew = 85°
Wingwall Data ~ 54+06
m = 6.33'
k = 1.50'
l = 22.0'
θ = 60°
z = 4:1
55
60
Temporary Easement
Proj. Line to be Constructed
N 24° 30' E
Survey Line
65° 30'
24° 30'
ST 51+92.90 (Proj.)
Exist. 60"x48" CSP
445.51'
59+81.69
27
22
26
23
½" Iron Pipe
B.M. #8 ~ Elev. 6914.77
H & G 50' Rt. 60+00
VPI 52+00
6925.00
VPC 50+00
VPT 54+00
400' VC
SSD = 655'
MDS = 70 MPH
1.780%
6930
6920
6910
6900
48
49
50
51
52
53
54
55
56
57
58
59
60
61

Courtesy of Colorado Department of Highways.

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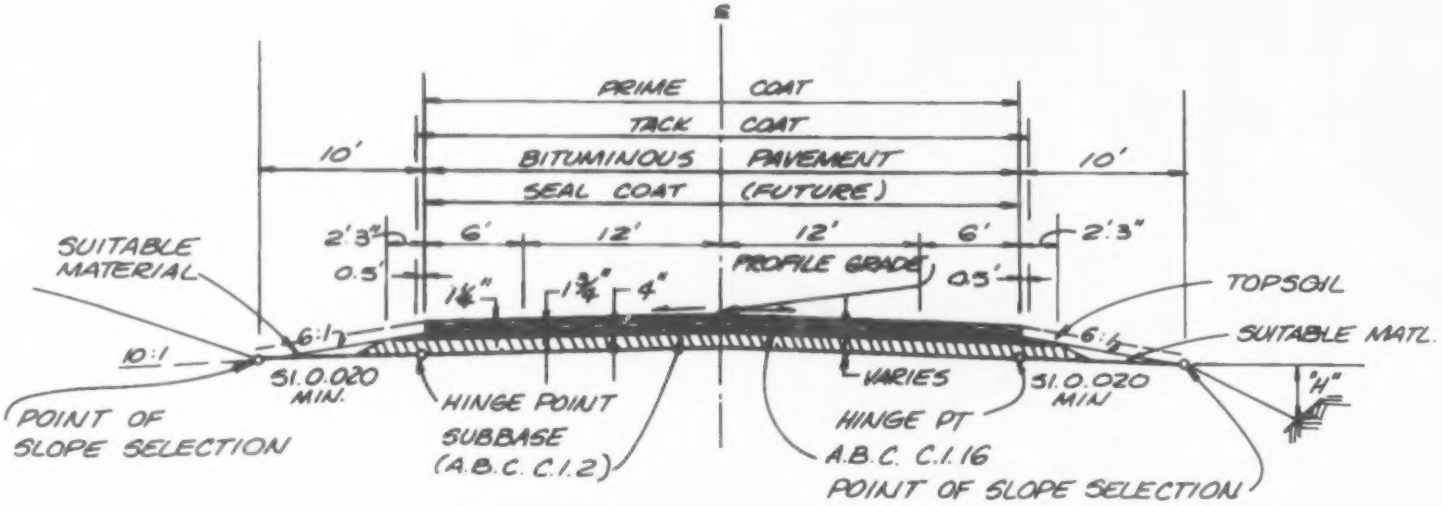
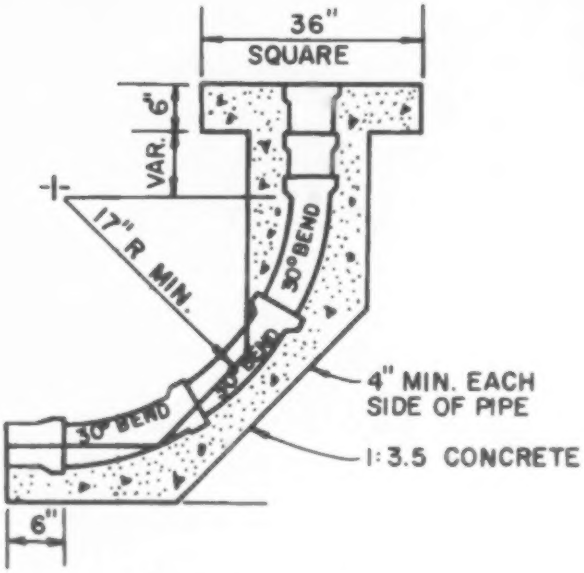
Typical Roadway Cross Section

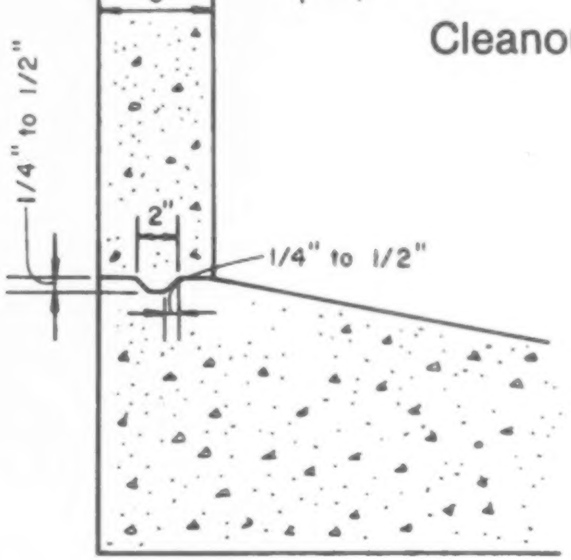

℄
PRIME COAT
TACK COAT
10'
BITUMINOUS PAVEMENT
10'
SEAL COAT (FUTURE)
2'3"
6'
12'
12'
6'
2'3"
0.5'
PROFILE GRADE
0.5'
SUITABLE MATERIAL
1¼"
1¾"
4"
TOPSOIL
6:1
6:1
SUITABLE MATL.
10:1
Sl. 0.020 MIN.
VARIES
Sl. 0.020 MIN
"H"
POINT OF SLOPE SELECTION
HINGE POINT
HINGE PT
SUBBASE (A.B.C. Cl. 2)
A.B.C. Cl. 16
POINT OF SLOPE SELECTION

Courtesy of Colorado Department of Highways.

Typical Structural Details

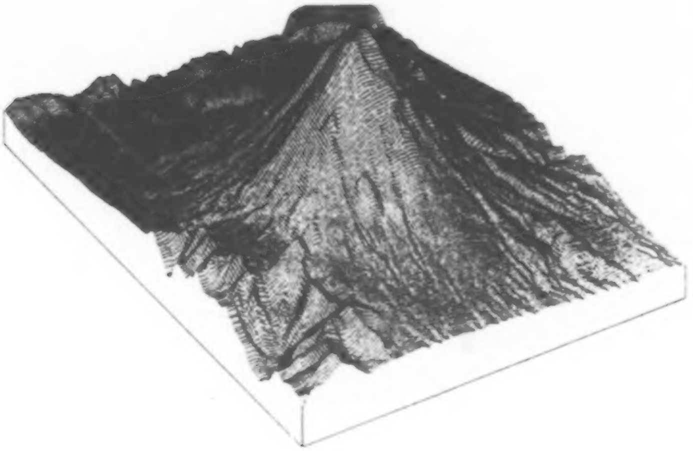

36"
SQUARE
6"
VAR.
17" R MIN.
30° BEND
30° BEND
30° BEND
4" MIN. EACH SIDE OF PIPE
1:3.5 CONCRETE
6"

Cleanout Detail

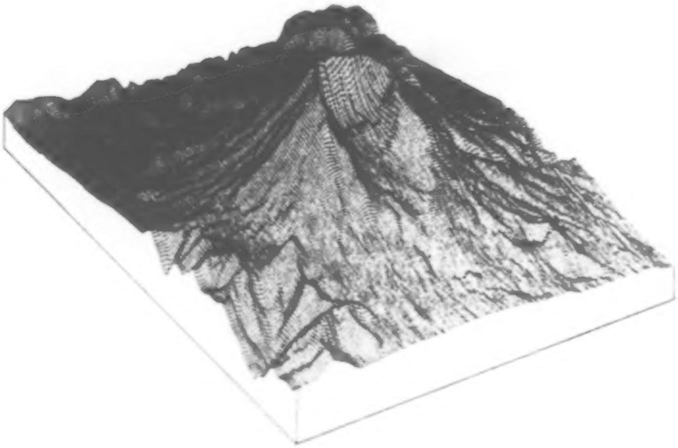

6"
1/4" to 1/2"
2"
1/4" to 1/2"

Detail: Key Construction Joint for Bottom and Walls

Typical Pictorial Drawing: Digital Elevation Model



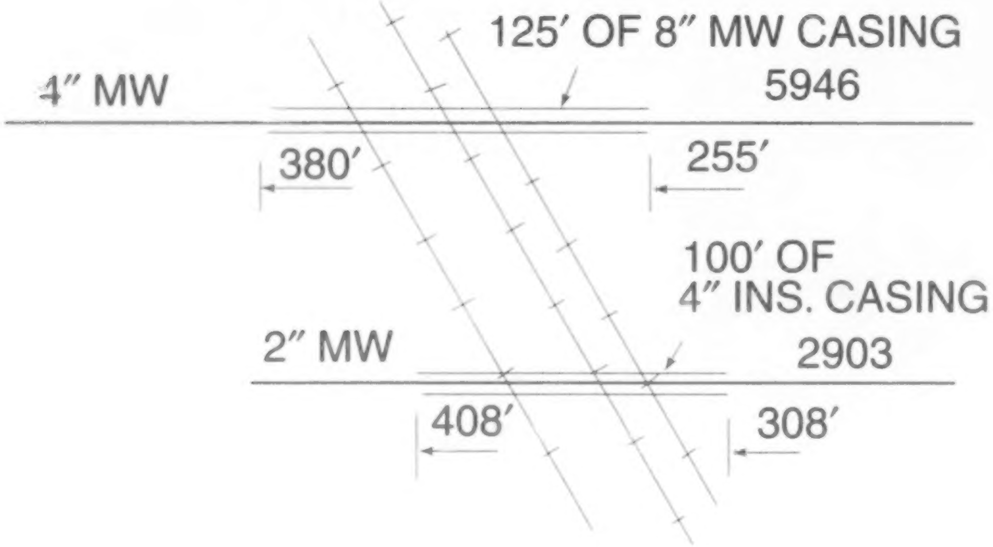
Mt. St. Helens, Washington (Before 1980 eruption)



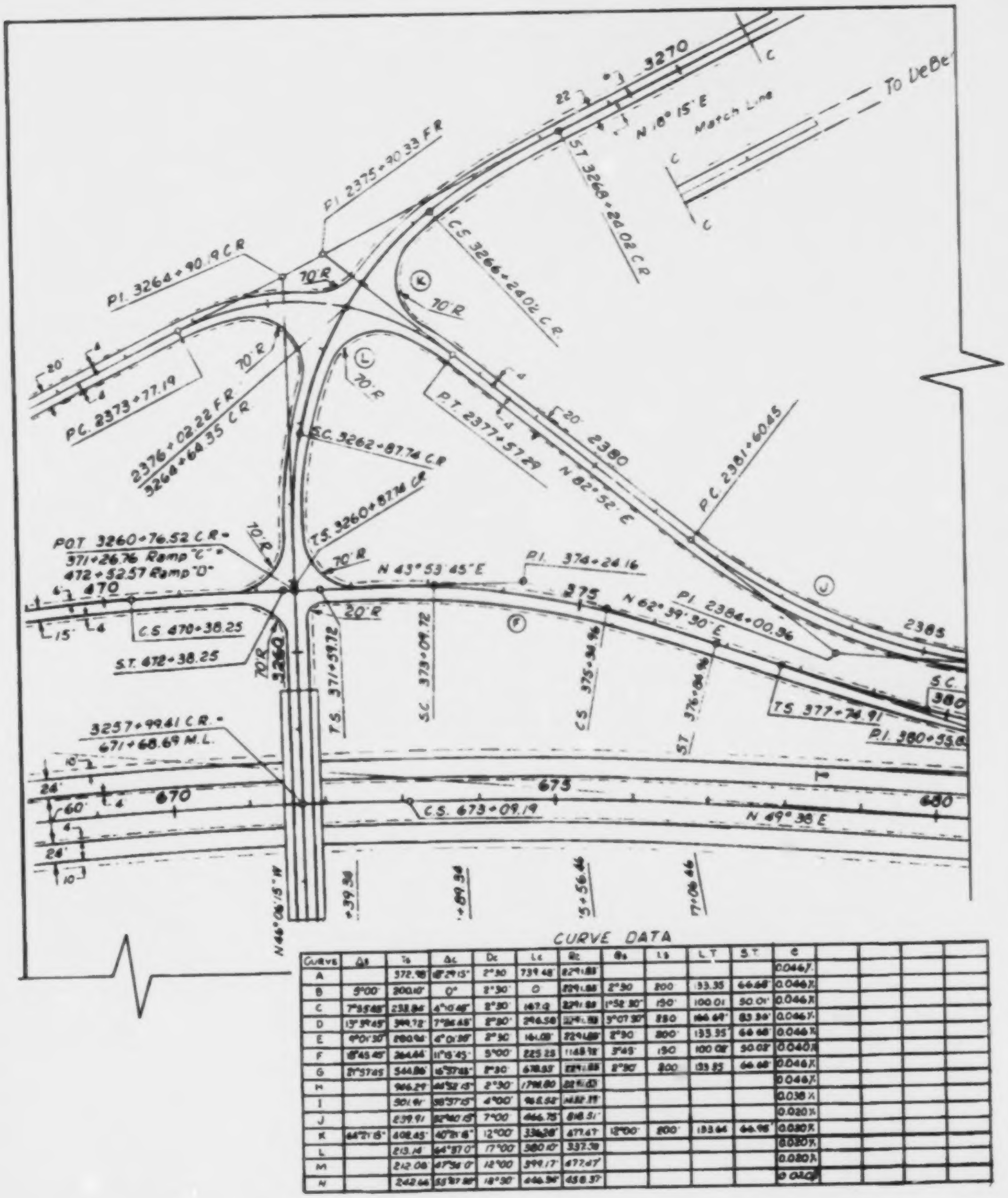
Mt. St. Helens, Washington (After 1980 eruption)

TM 14

Typical Schematic Diagram


125′ OF 8″ MW CASING
4″ MW
5946
380′
255′
100′ OF
4″ INS. CASING
2″ MW
2903
408′
308′

Typical Intersection Detail


3270
N 18° 15' E
Match Line
To DeBe
22
S.T. 3268+24.02 C.R.
C.S. 3266+24.02 C.R.
P.I. 2375+90.33 F.R.
P.I. 3264+90.9 C.R.
70' R
70' R
70' R
70' R
70' R
70' R
70' R
20' R
K
L
J
F
20'
4
P.C. 2373+77.19
2376+02.22 F.R.
3264+64.35 C.R.
S.C. 3262+87.74 C.R.
T.S. 3260+87.74 C.R.
P.T. 2377+57.29
2380
N 82° 52' E
P.C. 2381+60.45
POT 3260+76.52 C.R. = 371+26.76 Ramp "C" = 472+52.57 Ramp "D"
470
N 43° 53' 45" E
P.I. 374+24.16
375
N 62° 39' 30" E
P.I. 2384+00.96
2385
C.S. 470+38.25
S.T. 472+38.25
15'
3260
T.S. 371+59.72
S.C. 373+09.72
C.S. 375+34.96
S.T. 376+84.96
T.S. 377+74.91
P.I. 380+55.6
S.C.
380
3257+99.41 C.R. = 671+68.69 M.L.
10'
24'
60'
24'
10
670
675
C.S. 673+09.19
N 49° 38' E
680
N 46° 06' 15" W
+39.38
+89.34
5+56.46
7+06.46

CURVE DATA

CURVE	Δ_s	T_s	Δ_c	D_c	L_c	R_c	θ_s	L_s	L.T.	S.T.	e				
A		372.98'	18°29'15"	2°30'	739.48'	2291.83'					0.046%				
B	5°00'	200.10'	0°	2°30'	0	2291.83'	2°30'	200	133.35	66.68'	0.046%				
C	7°35'45"	233.86	4°10'45"	2°30'	167.0	2291.83	1°52'30"	150'	100.01	50.01'	0.046%				
D	13°59'45"	399.72'	7°26'45"	2°30'	296.50	2291.83	3°07'30"	250	166.69'	83.34'	0.046%				
E	4°01'30"	200.94	4°01'30"	2°30'	161.00'	2291.83'	2°30'	200'	133.35'	66.68'	0.046%				
F	18°45'45"	264.44	11°15'45"	5°00'	225.25	1145.92	3°45'	150	100.08'	50.02'	0.040%				
G	21°57'45	544.86	16°57'45"	2°30'	678.55'	2291.83	2°30'	200	133.35	66.68'	0.046%				
H		906.29'	66°52'15"	2°30'	1798.80	2291.83					0.046%				
I		501.61'	58°37'15"	4°00'	1465.52'	1432.39'					0.038%				
J		239.91	32°40'15"	7°00'	466.75'	818.51'					0.020%				
K	64°21'15"	408.45'	40°21'15"	12°00'	336.28'	477.47'	12°00'	200'	133.64	66.95'	0.020%				
L		213.14'	64°37'0"	17°00'	380.10'	337.30					0.020%				
M		212.08'	47°56'0"	12°00'	399.17'	477.47'					0.080%				
N		242.66	55°37'30"	12°30'	446.34'	458.37'					0.020				

Courtesy of Colorado Department of Highways.

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TM 16

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Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Develop a display of different scale topographic maps.
- Have a speaker from a civil engineering firm speak to class about the importance of accuracy and the need for precision.
- Review with students Unit 5 in MAVCC's *Basic Drafting*, Third Edition.
- Obtain brochures and other materials dealing with map scales and measurement from the USGS. Refer to resources identified in Unit 1.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- Brinker, Russell C. and Paul R. Wolf. *Elementary Surveying*, 9th ed. New Jersey: Prentice-Hall, Inc., 1998.
- Colley, Barbara C. *Practical Manual of Land Development*, 3rd ed. New York: McGraw-Hill, Inc., 1998.
- *Definitions of Surveying and Associated Terms*. American Congress on Surveying and Mapping and the American Society of Civil Engineers. (out of print)
- *Glossaries of BLM Surveying and Mapping Terms*, 2nd ed. Bureau of Land Management/U.S. Department of the Interior.
- Madsen, David and Terence Shumaker. *Civil Drafting Technology,* 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1997.

Suggested Activities

- *Map Accuracy.* Reston VA: U.S. Department of the Interior, Geologic Survey, National Cartographic Information Center.
- Thompson, Morris M. *Maps for America*, 3rd ed. USGS, United States Department of the Interior, 1987. (out of print)
- USGS Brochure-*Understanding Map Scales/Map Types.*
- Wattles, Gurdon. *Survey Drafting*, 2nd ed. Orange, CA: Gurdon H. Wattles Publications, 1981.
- Wirshing, Roy H. and James R. Wirshing. *Civil Engineering Drafting.* New York: Glencoe/McGraw-Hill, Inc., 1983, Imprint 1993.

Answers to Assignment Sheets

Assignment Sheet 1

Convert a Representative Fraction to a Graphic Scale

Step I—4.73 miles

Step II—2.11 inches

Step III—Evaluated to the satisfaction of the instructor

Assignment Sheet 2

Measure With a Civil Engineer's Scale

LINE	1″=10′	1″=20′	1″=300′	1″=40′	1″=500′	1″=60′	1″=10 MILES
A	44′	88′	1320′	176′	2200′	264′	44 miles
B	37′	74′	1110′	148′	1850′	222′	37 miles
C	31′	62′	930′	124′	1550′	186′	31 miles
D	42′	84′	1260′	168′	2100′	252′	42 miles
E	12′	24′	360′	48′	600′	72′	12 miles
F	30′	60′	900′	120′	1500′	180′	30 miles

Assignment Sheet 3

Measure Distances on a 7.5 Minute Quadrangle

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 4

Use a Civil CAD Software Program to Set Project Parameters

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match terms related to map scales and measurement with their definitions. Definitions continue on the next page.

1. Accuracy
2. Deviation
3. English system
4. Full-divided scale
5. Grad or Gons
6. Graduations
7. Hectare
8. Meter
9. Metric system
10. Neutral scale
11. Nominal
12. NTS
13. Open-divided scale
14. Precision
15. Representative fraction
16. Scale
17. Scale ratio
18. SI
19. Significant digit
20. Tolerance
21. U.S. customary units

_____ a. The degree of mutual agreement between individual measurements, namely repeatability and reproducibility

_____ b. The degree of conformity of a measured or a calculated value to some recognized standard or specified value

_____ c. A scale expressed as a fraction or a ratio

_____ d. Any numeral that is necessary to define a value or quantity

_____ e. Abbreviation meaning "not-to-scale"

_____ f. A simple ratio or fraction

_____ g. An instrument used as a standard or reference when drawing an object to a proportional size

_____ h. A scale with only the end unit subdivided into fractional parts

_____ i. A scale with the basic units subdivided throughout the length of the scale

_____ j. A decimal system of weights and measures based on the meter and the kilogram

_____ k. A relationship between dimensional values used to reduce or enlarge the size of an object so that it can be drawn proportionally

_____ l. Units based upon the yard and the pound commonly used in the United States

_____ m. The metric system standard for linear measurement

_____ n. Is equivalent to a square having sides of 100 meters

_____ o. Variation from a specified dimension or design requirement, usually defining upper and lower limits

_____ p. Describes a value assigned for the purpose of convenient designation; existing in name only

_____ q. The total range of variation permitted for size, position, or other required quantity

_____ r. The subdivisions in a scale unit, all of which are equal in size or length

_____ s. International system of units (metric system)

_____ t. An angular unit of measurement

_____ u. "Foot" is the basic unit of measurement

Objective 2

Complete the following chart of standard measurements and their equivalents.

a. 1 mile = _______________ feet = _______________ chains

b. 1 inch = _______________ centimeters

c. 1 rod = _______________ yards

d. 1 furlong = _______________ chains

e. 1 chain = _______________ rods = _______________ links

f. 1 chain = _______________ yards = _______________ feet

g. 1 square mile = _______________ acres

h. 1 acre = _______________ sq. chains

i. 1 centimeter = _______________ millimeters

j. 1 meter = _______________ yards

Objective 3

Select true statements concerning accuracy and precision by placing an "X" in the blanks next to the true statements.

_____ a. Accuracy refers to correctness.

_____ b. An accurate measurement implies a level of precision.

_____ c. Precision refers to a degree of measurement.

_____ d. The degree of precision depends on the size of the parcel to be measured.

_____ e. A number can be both accurate and precise.

Objective 4

Complete the following statements about choosing a map scale by filling in the blanks with the correct answers.

a. The choice of map scale depends on ______________ you intend to use the map.

b. A large scale map shows ______________ detail and ______________ land area.

c. A small scale map shows ______________ detail and ______________ land area.

Objective 5

Select true statements concerning characteristics of map scales by placing an "X" in the blanks next to the true statements.

_____ a. Map scale is the relationship between a distance on a map and the corresponding distance on the ground.

_____ b. A map scale expressed as 1:50,000 means that one unit of measurement on the map represents 50,000 of the same units on the earth's surface.

_____ c. The first number (map distance) is always 1. The second number (ground distance) differs for each scale.

_____ d. The larger the second number, the larger the scale of the map.

Objective 6

List the three ways maps scales are expressed.

a. ____

b. ____

c. ____

Objective 7

Match the ranges of map scales with the appropriate map scale classifications.

1. 1 in = 1000 ft. 2. 1 in = 100 ft. 3. 1 in = 100 to 1000 ft.

_____ a. Small scale maps

_____ b. Medium scale maps

_____ c. Large scale maps

Objective 8

List three factors affecting the selection of a map scale.

a. ____

b. ____

c. ____

Written Test

Objective 9

Match common types of maps with their corresponding map scales.

1. Cadastral maps
2. Engineering maps
3. Geographic maps
4. Topographic maps

_____ a. Normally range from 1″ = 20 ft. to 1″ = 400 ft.

_____ b. Usually greater than 6 inches to one mile which is necessary to obtain required accuracy

_____ c. Vary from a few miles to an inch to several hundred miles to the inch

_____ d. Depending upon degree of development in the region, can vary from smaller scales such as 1:125,000 to larger scales such as 1:24,000

Objective 10

Define a minute on the globe.

____

____

Objective 11

Select characteristics of a quadrangle scale by placing an "X" in the appropriate blanks.

_____ a. Set by the Department of Commerce

_____ b. Set by the Bureau of Land Management

_____ c. Set by the United States Geologic Survey

_____ d. Measures a standard four-sided area

_____ e. Measures irregular areas

_____ f. Bounded by lines of longitude and latitude

_____ g. Most U.S. topographic maps cover 15 minutes latitude and longitude and are drawn at 1:62,500 quadrangle scale

Written Test

Objective 12

Match quadrangle scales commonly used on USGS topographic maps with their one inch equivalents.

Scales

1. 1:20,000
2. 1:24,000
3. 1:30,000
4. 1:31,680
5. 1:62,500
6. 1:63,360
7. 1:125,0000
8. 1:250,000
9. 1:1,000,000

1 inch equals

_____ a. Exactly 1/2 mile

_____ b. Exactly 2,000 feet

_____ c. Exactly 1 mile

_____ d. Exactly 2,500 feet

_____ e. Approximately 1 mile

_____ f. Approximately 16 miles

_____ g. Approximately 1,667 feet

_____ h. Approximately 4 miles

_____ i. Approximately 2 miles

Scales

10. 1:100,000
11. 1:50,000
12. 1:25,000
13. 1:20,000

1 cm represents

_____ j. 0.20 km

_____ k. 0.25 km

_____ l. 0.50 km

_____ m. 1.00 km

Objective 13

Select true statements concerning characteristics of graphic scales by placing an "X" in the blanks next to the true statements.

_____ a. Are like small rules that measure distances on a map

_____ b. Consist of a bar drawn at the same scale as the map

_____ c. Begin at 50′

_____ d. Are used any time that a map may become subject to reduction, enlargement, or reproduction for use in reports

_____ e. Are most often used on engineering maps

_____ f. Are usually located in the margins or near the north arrow or legend of the map

Written Test

Objective 14

Select true statements concerning published map accuracy standards by placing an "X" in the blanks next to the true statements.

_____ a. On maps with scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than $^1/_{30}$ inch.

_____ b. On maps with scales of 1:30,000 or smaller, the error factor is $^1/_{30}$ inch.

_____ c. These limits of accuracy apply in all cases to positions of well-defined points that are easily visible or recoverable on the ground such as monuments, intersections of roads, or railroads.

_____ d. On contour maps (all publication scales), not more than 5 percent of the elevations tested shall be in error more than one-half the contours interval.

_____ e. In checking elevations, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

Objective 15

Match types of scales used in civil drafting with their descriptions.

1. Civil engineer's scale
2. Metric scale
3. Architect's scale

_____ a. Used primarily for drawings of buildings, piping systems, and other large structures which must be drawn to a reduced scale to fit on a standard sheet size; only occasionally used for civil work; has one full-size scale and ten reduced-size scales

_____ b. Used for civil engineering work; graduated in units of one inch divided into 10, 20, 30, 40, 50, and 60 parts

_____ c. Used primarily when the International System of Units (SI) metric method of measurement is in use; graduated in millimeters, and uses scale ratios of 1:1, 1:2, 1:5, and 1:25

Objective 16

Select the true statement concerning map scales in CAD by placing an "X" in the blank next to the true statement.

_____ a. All data downloaded to the computer is at a 1:1 scale.

_____ b. The scale for final map presentation is determined at the time of plotting which leaves original data at a 1:2 scale.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 14
b. 1
c. 10
d. 19
e. 12
f. 15
g. 16
h. 13
i. 4
j. 9
k. 17
l. 21
m. 8
n. 7
o. 2
p. 11
q. 20
r. 6
s. 18
t. 5
u. 3

Objective 2

a. 5280 feet, 80 chains
b. 2.54 centimeters
c. 5.5 yards
d. 10 chains
e. 4 rods, 100 links
f. 22 yards, 66 feet
g. 640 acres
h. 10 sq. chains
i. 10 millimeters
j. 1.0936 yards (answer may be rounded)

Objective 3

a, d

Objective 4

a. how
b. more, less
c. less, larger

Objective 5

a, b, c

Objective 6

a. By ratio or representative fraction
b. By equivalence
c. Graphically

Objective 7

a. 1
b. 3
c. 2

Objective 8

Any three of the following:

a. Size and character of the area to be shown
b. The form that the map is to be presented in
c. Purpose of the map
d. Cost of preparation and length of service (sometimes a consideration)
e. Required precision

Objective 9

a. 2
b. 1
c. 3
d. 4

Answers to Written Test

Objective 10	A minute is an angular unit of measurement equal to one sixtieth of a degree
Objective 11	c, d, f
Objective 12	a. 4 b. 2 c. 6 d. 3 e. 5 f. 9 g. 1 h. 8 i. 7 j. 13 k. 12 l. 11 m. 10
Objective 13	a, b, d, f
Objective 14	a, c, e
Objective 15	a. 3 b. 1 c. 2
Objective 16	a

Unit 2 — Map Scales and Measurement

Prerequisites:
Unit 1

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 9.

☐ 4. **Do** Assignment Sheet 1, "Convert a Representative Fraction to a Graphic Scale."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat steps 4 and 5, reviewing steps and examples provided as part of the assignment.

☐ 6. **Do** Assignment Sheet 2, "Measure With a Civil Engineer's Scale."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 6 and 7.

☐ 8. **Study** Information Sheet, Objectives 10 through 15, and Student Supplements 1 and 2.

☐ 9. **Do** Assignment Sheet 3, "Measure Distances on a 7.5 Minute Quadrangle."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat steps 8 through 10.

Learning Activities Sheet

☐ 11. **Study** Information Sheet, Objective 16.

☐ 12. **Go** To computer and complete Assignment Sheet 4, "Use a Civil CAD Software Program to Set Project Parameters."

☐ 13. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 14. If the evaluation is not satisfactory, meet with instructor to determine needed improvements and repeat steps 11 through 13.

☐ 14. **Check** With instructor for any additional assignments to be completed.

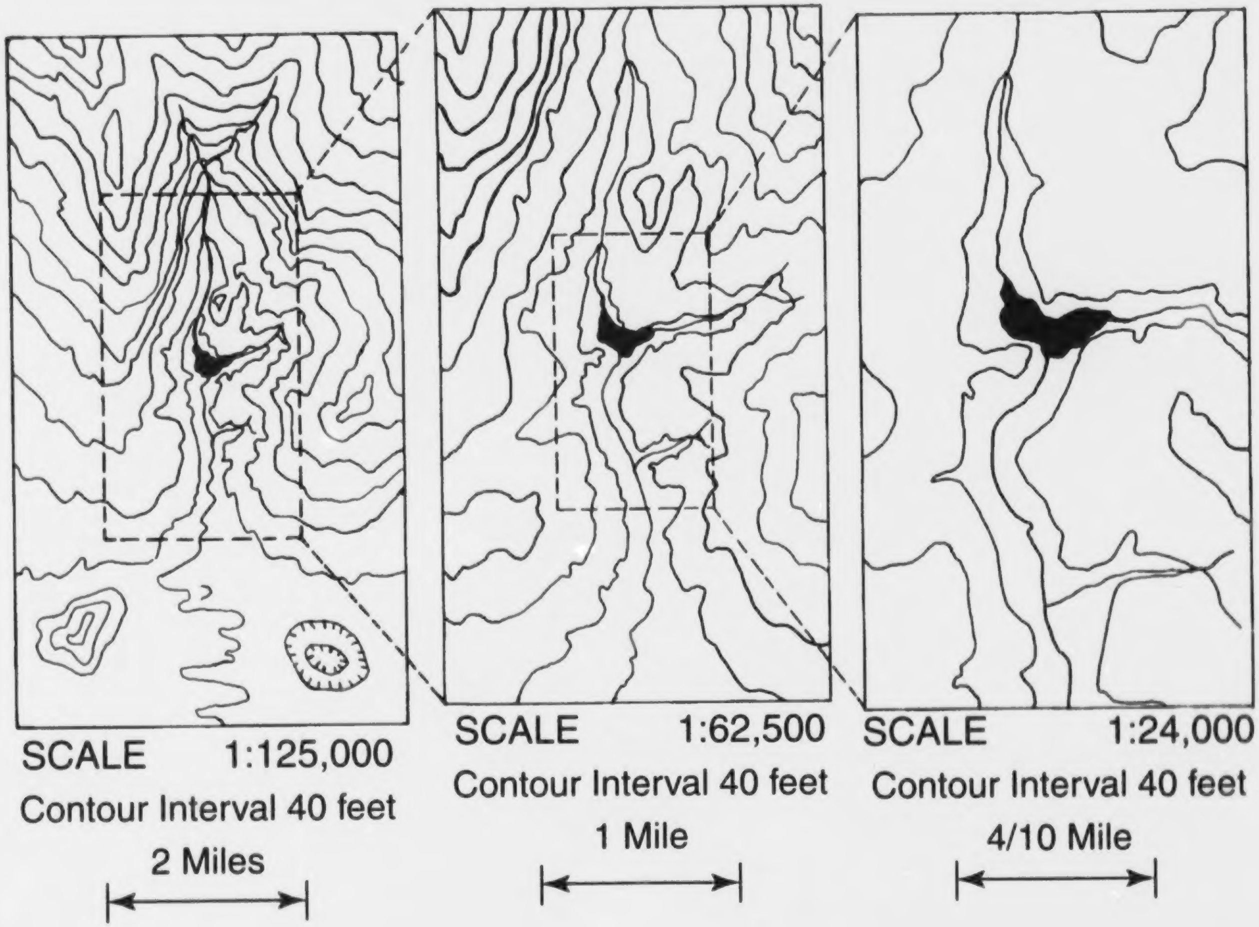
☐ 15. **Do** Additional assignments listed below.

☐ 16. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 17. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Comparison of Topographic Map Scales

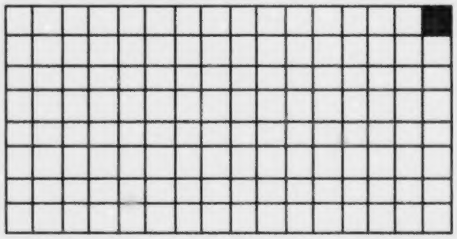

SCALE 1:125,000
Contour Interval 40 feet
2 Miles
SCALE 1:62,500
Contour Interval 40 feet
1 Mile
SCALE 1:24,000
Contour Interval 40 feet
4/10 Mile

Application of Metric Scales

Metric mm:mm	Application
1:1 1:2 1:3 1:5 1:10	Machine drawings
1:20 1:25 1:33 1/3	Architectural construction details
1:75 1:100 1:200	Architectural plans and elevations Architectural plot plans
1:500 1:1250 1:2500 1:10,000 1:50,000	Maps (civil drawings)

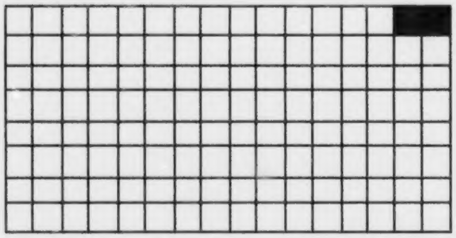
Comparison of Standard USGS Quadrangle Maps

Note: Illustrated below is the relative comparison of the size of the area covered by the various map series.



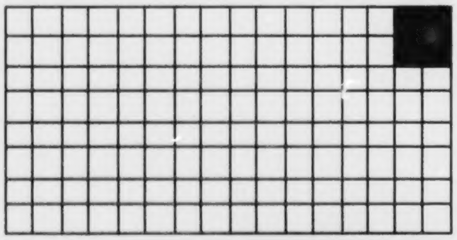
7.5 Minute Series

Map scale[1]	1:24 000
Map to ground ratio	1 inch represents 2000 feet
Area covered	49-17 square miles
Paper size (approx.)	22″ x 27″
Contours and elevations[2]	shown in feet



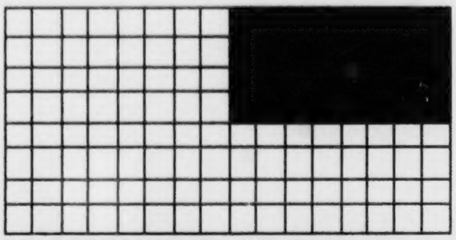
7.5 X 15 Minute Series

Map scale	1:25 000
Map to ground ratio	1 inch represents 2083 feet
Area covered	100-140 square miles
Paper size (approx.)	24″ x 40″
Contours and elevations	shown in meters



15 Minute Series

Map scale[3]	1:62 500
Map to ground ratio	1 inch represents about 1 mile
Area covered	197-282 square miles
Paper size (approx.)	18″ x 22″
Contours and elevations[2]	shown in feet



30 X 60 Minute Series

Map scale	1:100 000
Map to ground ratio	1 inch represents 1.6 miles
Area covered	1578-2167 square miles
Paper size (approx.)	29″ x 44″
Contours and elevations[2]	shown in meters

1 X 2 Degree Series

Map scale	1:250 000
Map to ground ratio	1 inch represents about 4 miles
Area covered	4580-8669 square miles
Paper size (approx.)	22″ x 32″
Contours and elevations[2]	shown in feet

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[1] 1:25 00 scale on selected maps

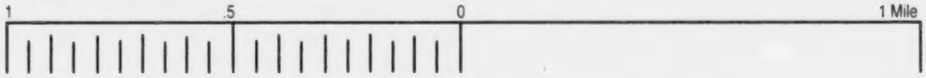
[2] Shown in meters on selected maps

[3] 1:50 000 scale on selected maps

Typical USGS Quadrangle Maps Graphic Scales

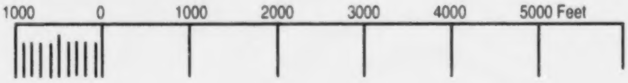
Mile Scale 1:24,000

Use this scale to measure distance in miles on a 1:24,000-scale map.



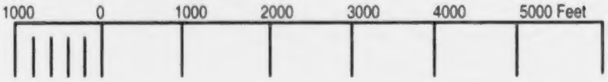
Foot Scale 1:24,000

Use this scale to measure distance in feet on a 1:24,000-scale map.


1000
0
1000
2000
3000
4000
5000 Feet

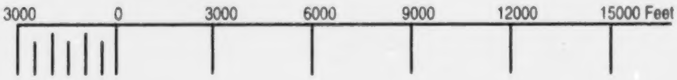
Foot Scale 1:25,000

Use this scale to measure distance in feet on a 1:25,000-scale map.


1000
0
1000
2000
3000
4000
5000 Feet

Foot Scale 1:63,360

Use this scale to measure distance in feet on a 1:63,360-scale map.


3000
0
3000
6000
9000
12000
15000 Feet

U.S. Geological Survey

Unit 3

Computer Applications in the Civil Engineering Field

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Information Sheet 3–5

Assignment Sheets

1—Research Available CAM Software and the Hardware Requirements 3–23
2—Research Computer Applications in the Civil Engineering Field 3–25
3—Import and Print Out an ASCI Point File Using a Civil CAD Software Program 3–29

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Collect vendor brochures on CAD systems and have students compare applications and capabilities.
- Invite a computer vendor to come in and demonstrate their CAD system.
- Take a field trip to a civil engineering firm and observe the computer applications.
- Make a display board of various computer drawings and their mapping application.
- Have students go online and find examples of the following:
  - — Digital elevation model
  - — Digital line graph
  - — Land use imagery
  - — Coordinate geometry
  - — Satellite imagery
  - — Orthorectified imagery
  - — Digital orthophotographs

  Refer them to Unit 1, Student Supplement 4, for suggestions on websites to locate examples. Have students make a list of where they found the computer images.
- Write to civil CAD software vendors for demonstration software and CD-ROMs.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- *AUTOCAD Map Software*, Autodesk Inc.
  San Rafael, CA
  1-800-964-6432
  www.autodesk.com
- Colley, Barbara C. *Practical Manual of Land Development*, 3rd ed. New York: McGraw-Hill, Inc., 1998.
- *Fundamental Training Manual, Advantage Series 13*. Dubuque, IA: Eagle Point Software, 1995.
- Korte, George B. *The GIS Book*, 4th ed. Santa Fe, NM: OnWord Press, 1997.
- *Road Calc.* Dubuque, IA: Eagle Point Software, 1997.
  www.eaglepoint.com
- *Softdesk Technical Resource Team.* Softdesk Civil I Certified Courseware. Santa Fe, NM: OnWord Press, 1996.
- *Survey Tutorial.* Dubuque, IA: Eagle Point Software, 1996.
- Thompson, Morris M., *Maps for America*, 3rd ed. USGS, United States Department of Interior, 1987. (out of print)
- *US Geo Data.* United States Department of Interior, USGS, Earth Science Information Center (ESIC). 800-USA-MAPS.

Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match terms related to civil mapping computer software with their definitions. Terms and definitions continue on the next three pages.

Note: Matching terms appear on the same page as definitions.

1. CPU
2. Merge
3. Photogrammetrically digitized
4. Pixel
5. Software
6. Topological relationships
7. Topology
8. Two-dimensional data
9. User interface
10. Window

_____ a. Instruction information for the computer

_____ b. Refers to how data elements relate to each other within the database; in particular, how a change to one element affects other elements

_____ c. The smallest discrete element which makes up an image

_____ d. Part of the computer that performs the calculations and logic

_____ e. Method by which the human operator communicates with the various databases and applications modules

_____ f. To take two or more maps or data sets and combine them into a single, coherent map or database without redundant information

_____ g. Rectangular frame with a specified size and location on the screen of an interactive graphics system, and within which a portion of the map is displayed

_____ h. Aerial data in two dimensions, such as northing-easting or latitude-longitude

_____ i. Digitized from aerial photographs and geodetic control data by means of special instruments, providing three-dimensional coordinates

_____ j. A branch of geometrical mathematics which is concerned with order, contiguity, and relative position, rather than actual linear dimensions

Written Test

11. Digitizing
12. Graphic entities
13. Grid
14. Hardware
15. Import
16. Node
17. Off-line
18. Overlay
19. Raster
20. Scanning
21. Spatial data
22. TIN
23. Topological error checking

_____ k. Process of converting an analog image or map into a digital format usable by a computer

_____ l. Transmission of information between a computer and a peripheral unit before or after, but not during processing

_____ m. Data pertaining to the location of geographical entities together with their spatial dimensions; classified as point, line, area or surface

_____ n. Pattern of horizontal, parallel scan lines comprising the image on a cathode ray tube screen, on which each scan line consists of segments varying in intensity

_____ o. Entities which are graphically portrayed as geometric shapes or symbols on the source document

_____ p. Process of ensuring that the logical consistency of the data is intact; that is, all polygons are closed, all arcs are connected to nodes, etc.

_____ q. Process of bringing data or software from another system into a system

_____ r. A data structure which describes a three-dimensional surface as a series of irregularly shaped triangles

_____ s. Process of using an electronic input device to convert analog information such as maps, photographs, or overlays, into a digital format usable by a computer

_____ t. A network of uniformly spaced horizontal and vertical lines that enclose an area (a cell) with an associated value assigned

_____ u. Data layer usually dealing with only one aspect of related information which is used to supplement the database

_____ v. Represents the intersection points and the endpoints of lines; each is uniquely numbered and is located by a pair of X, Y geographic coordinate values

_____ w. The computer itself and its peripherals

24. Attribute
25. CPU time
26. Data capture
27. DTM
28. Hard copy
29. Interactive
30. Layers
31. Modem
32. On-line
33. Resolution
34. Spreadsheet
35. Topological

_____ x. Measure of the ability of a display system to distinguish detail under certain specific conditions; normally expressed in lines per millimeter, meters per pixel, dots per inch, etc.

_____ y. A technique for translating three-dimensional topographic information onto a two-dimensional surface

_____ z. Descriptive characteristic of a feature

_____ aa. Actual computational time necessary to process a set of instructions in the arithmetic and logic units of the computer

_____ bb. A matrix of rows and columns used for a wide variety of calculations and comparisons of information

_____ cc. A device which interprets computers' electronic impulses into frequencies within the audio range, and vice versa, for the use of telephone lines to communicate computer information

_____ dd. Printed paper or film copy of machine output in a visually readable form such as printed reports, listings, graphs, etc.

_____ ee. Refers to such properties or geometric figures as adjacency that are not altered by distortion as long as the surface is not torn

_____ ff. The various "overlays" of data, each of which normally deals with one thematic topic

_____ gg. Transmission of information between a computer and a terminal or display device while processing is occurring

_____ hh. Series of operations required to encode data in a computer readable digital form (digitizing)

_____ ii. System allowing two-way electronic communication between the user and the computer

Written Test

36. Automatic snapping
37. CADD
38. CAM
39. Database
40. Database creation
41. Database development
42. Database management system
43. Digital data
44. Digital elevation model
45. Digital terrain model
46. Digitize
47. GIS
48. Hard disk
49. Spatial analysis

_____ jj. Of, or relating to data in the form of digits; data displayed, recorded, or stored in binary notation

_____ kk. Analytical techniques associated with the study of the location of geographical entities together with their spatial dimensions

_____ ll. System capability for completing a line segment whose end falls within a predefined proximity to an intersection or node, without operator intervention

_____mm. A map including a wide variety of information about a particular geographic area; usually on electronic medium

_____ nn. A collection of information related by a common fact or purpose

_____ oo. A land surface represented in digital form by an elevation grid or lists of three-dimensional coordinates

_____ pp. Computer-aided design and drafting

_____ qq. Software that assists the operator in standard mapping operations

_____ rr. Permanent magnetic disk within a computer that holds the permanent information stored

_____ ss. To translate two-dimensional information into an electronic format for use in a computer

_____ tt. A file with terrain elevations recorded at the intersections of a fine grid and organized by quadrangle to be the digital equivalent of the elevation data on a topographic base map

_____ uu. Process of determining what elements will be included in a database and their internal relationships

_____ vv. Software designed to access and structure a database

_____ww. Process of bringing data into the electronic environment of a database for later use

Written Test

Objective 2 List six basic CADD operations performed by a civil technician.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Objective 3 Select from a list the advantages of computer applications in mapping by placing an "X" in the blanks next to the advantages.

_____ a. Know where to find information

_____ b. Data is more precise

_____ c. CAD increases cost of map production but it is worth it because it speeds up map creation

_____ d. Standardization of layouts

_____ e. Map data can be protected by a single level of security

_____ f. Data can be separated into layers

_____ g. Quick map editing

_____ h. Maps can be plotted or printed in color

_____ i. Databases can be customized based on three criteria: color, layout, and type of information

Objective 4 Define digital cartography. ______________________________

____

Objective 5 List eight types of geographic or land systems that utilize digital data information.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

Objective 6

List five types of digital cartographic and geographic data.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

Objective 7

Select true statements concerning characteristics of digital cartographic and geographic data by placing an "X" in the blanks next to the true statements.

_____ a. Digital elevation models are records of terrain elevations at regularly spaced horizontal intervals.

_____ b. Elevation data are available in 7.5 minute, 15 minute, 30 minute, and 90-degree units.

_____ c. Data consists of a regular array of elevations referenced digitally to the Universal Transverse Mercator coordinate system.

_____ d. DLG's are the digital representation of the cartographic information on a map.

_____ e. DLG's are topologically structured.

_____ f. GNIS consists of five separate data categories.

_____ g. USGS Topographic Map Names Database is the official inventory of all topographic maps planned or published by the USGS.

_____ h. LULC maps display information on roads, trails, railroads, pipelines, and transmission lines.

_____ i. The National Mapping Program of the U.S. Department of the Interior has developed software to aid in data applications that may require geometric manipulation in surveying, geodesy, remote sensing, and photogrammetry.

Objective 8

List six types of computer aided map (CAM) software.

a. ______________________________
b. ______________________________
c. ______________________________
d. ______________________________
e. ______________________________
f. ______________________________

Objective 9

Select true statements about features of each of the main civil software modules by placing an "X" in the blanks next to the true statements.

_____ a. The digital terrain module is the most important link between data taken in the field and the resulting map created in the office.

_____ b. Data files contain terrain data features such as center line of roads, edge of road, ridge lines, power lines, etc.

_____ c. COGO is used to check the traverse and define the boundary line of the site.

_____ d. The survey uses mathematical routines to balance and adjust all points relative to a survey traverse.

_____ e. The earthwork module can set points graphically at a slope or at a grade.

_____ f. COGO plots and calculates horizontal and vertical curves.

_____ g. DTM is a tool to do site analysis through terrain modeling programs.

Objective 10

List five parameters required to be set for a computer mapping project.

a. ______________________________
b. ______________________________
c. ______________________________
d. ______________________________
e. ______________________________

Objective 11

List three other types of digital or computer enhanced mapping tools.

a. ______________________________
b. ______________________________
c. ______________________________

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a.	5	n.	19	aa.	25	nn.	39
b.	6	o.	12	bb.	34	oo.	45
c.	4	p.	23	cc.	31	pp.	37
d.	1	q.	15	dd.	28	qq.	38
e.	9	r.	22	ee.	35	rr.	48
f.	2	s.	20	ff.	30	ss.	46
g.	10	t.	13	gg.	32	tt.	44
h.	8	u.	18	hh.	26	uu.	41
i.	3	v.	16	ii.	29	vv.	42
j.	7	w.	14	jj.	43	ww.	40
k.	11	x.	33	kk.	49		
l.	17	y.	27	ll.	36		
m.	21	z.	24	mm.	47		

Objective 2

Any six of the following:

a. Create geometric shapes with or without specifying size
b. Create lines from the exact endpoints of other lines
c. Create lines perpendicular or parallel to other lines
d. Change the scale of all or a selected portion of a drawing
e. Rotate all or a portion of a drawing by a specific or unspecified amount
f. Create a parallel line at a specified offset distance
g. Create a mirror image of all or a portion of a drawing
h. Copy an area or one element of a drawing to another location or to multiple locations
i. Extend a line to some specified location
j. Trim a line
k. Create a line of specified bearing and distance
l. Create tangents to circular curves from specified points
m. Create a circular curve by specifying two elements of the curve data
n. Create a circular curve tangent to one or two lines by specifying two elements of the curve data
o. Label lines and curves with bearing and distances or curve data
p. Label coordinates
q. Trace information into the computer

Objective 3

b, d, f, g, h

Objective 4

Digital cartography—The collection, storage, processing, analysis and display of map data with the aid of computers

Answers to Written Test

Objective 5

Any eight of the following:

a. Transportation planning
b. Town and urban planning
c. Environmental impact studies
d. Land use planning
e. Mineral resource assessment
f. Wildlife habitat assessment
g. Resource management
h. Hydrologic modeling
i. Rangeland inventories
j. Irrigation potential determinations
k. Geologic assessments
l. Visual interpretations
m. Land cover diversity estimates
n. Vegetation inventories
o. Soil surveys
p. Forest fire behavior predictions
q. Earthquake hazards mapping
r. Coastal zone management
s. Environmental assessment
t. Geographic names analysis

Objective 6

Any five of the following:

a. Elevation data
b. Planimetric data
c. Geographic names information
d. Land use and land cover data
e. Software
f. Hydrography data
g. Transportation data

Objective 7

a, d, e, g

Objective 8

Any six of the following:

a. Site planning
b. Landscape design
c. Irrigation design
d. Construction details
e. Project manager
f. Virtual simulator
g. Surface modeling
h. Site analysis
i. Survey adjustment
j. Coordinate geometry
k. Road calculations
l. Drafting
m. Structural

n. Data collection
o. Data transfer
p. Profiles
q. Earthworks
r. Design
s. Hydrology tools
t. Imaging and scanning software
u. GIS (Graphic Information Systems)

Objective 9

b, c, d, e, g

Objective 10

Any five of the following:

a. Units
b. Precision
c. Formats
d. Drawing scales
e. Text size and style
f. Sheet size
g. Drawing border
h. Node attribute style

Objective 11

Any three of the following:

a. Unprocessed satellite imagery
b. Digital orthophotography
c. Instant imagery in CD-ROM
d. Spreadsheet

Unit 3

Computer Applications in the Civil Engineering Field

Prerequisites:
Units 1 and 2

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 9.

☐ 4. **Do** Assignment Sheet 1, "Research Available CAM Software and the Hardware Requirements."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 4 and 5.

☐ 6. **Study** Information Sheet, Objectives 10 and 11.

☐ 7. **Do** Assignment Sheet 2, " Research Computer Applications in the Civil Engineering Field."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, meet with instructor to determine needed improvements and repeat steps 7 and 8.

☐ 9. **Go** To computer and complete Assignment Sheet 3, "Import and Print Out an ASCI Point File Using a Civil CAD Software Program."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 9 and 10.

Learning Activities Sheet

☐ 11. **Check** With instructor for any additional assignments to be completed.

☐ 12. **Do** Additional assignments listed below.

____

____

____

☐ 13. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 14. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Teacher Supplement 1—Computer Software Resources for Mapping

1. Autodesk, Inc.
   111 McInnis Parkway
   San Rafael, CA 94903 USA
   http://www.autodesk.com

2. Eagle Point
   4131 Westmark Drive
   Dubuque, IA 52002
   http://www.netins.net/showcase/eaglewww

3. i^3 Information Integration and Imaging
   145 East Mountain Avenue
   Fort Collins, CO 80524
   http://www.i3.com

4. Blue Highway Map Company
   P.O. Box 307
   Caledonia, IL 61011
   800-627-2923 for a demo disk

5. USGS
   800-USA-MAPS
   - LULC Index Map free on request
   - Digital Cartographic Sampler (US Geodata Sampler) for nominal charge
   - DEM 1 :24,000—Scale index available free on request

Teacher Supplement 2—MAVCC Point Statistics Printout

```
1,3609.132000,3906.908000,7600.000000,START

2,3098.785000,3678.467000,7578.971000,BS TP-SW COR

3,3754.248000,3682.697000,7584.402000,PIN

4,3564.843000,3602.346000,7598.630000,EOR1

5,3568.424000,3611.797000,7598.775000,EOR2

6,3515.665000,3640.356000,7596.521000,EOR2 PC

7,3511.525000,3630.586000,7596.468000,EOR1 PC

8,3476.638000,3650.341000,7593.086000,EOR1 POC

9,3426.722000,3652.013000,7589.180000,EOR1 PT

10,3378.041000,3644.063000,7586.546000,EOR1

11,3335.382000,3633.003000,7584.396000,EOR1

12,3332.526000,3642.323000,7584.571000,EOR3

13,3400.987000,3658.383000,7588.270000,EOR3

14,3448.802000,3663.017000,7591.031000,EOR3 PC

15,3426.508000,3680.719000,7588.097000,NO4 REBARCAP

16,3475.207000,3670.793000,7592.351000,EOR3 POC

17,3489.172000,3692.017000,7593.238000,EOR3 PT

18,3505.795000,3655.474000,7595.220000,EOR2 POC

19,3502.271000,3688.999000,7593.434000,EOR2 PT

20,3508.190000,3728.388000,7593.131000,EOR2

21,3496.193000,3731.551000,7593.285000,EOR3

22,3518.371000,3810.079000,7595.108000,EOR3
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Teacher Supplement 2

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23,3529.131000,3806.285000,7595.303000,EOR2

24,3569.463000,3905.033000,7599.644000,EOR2

25,3559.725000,3909.340000,7599.783000,EOR3

26,3575.020000,3953.989000,7600.388000,EOR3

27,3586.003000,3948.339000,7600.530000,EOR2

28,3593.033000,3971.749000,7600.415000,EOR2

29,3580.906000,3974.306000,7600.419000,EOR3

30,3591.208000,4005.623000,7600.608000,EOR3

31,3601.284000,4001.573000,7600.182000,EOR2 PC

32,3618.336000,4032.769000,7599.612000,EOR2 POC

33,3640.317000,4055.430000,7598.719000,EOR2 PT

34,3662.736000,4072.582000,7597.195000,EOR2

35,3601.841000,4035.231000,7600.150000,EOR3

36,3599.952000,4057.819000,7600.099000,EOR3

37,3587.717000,4093.833000,7599.512000,EOR3 PC

38,3573.581000,4113.101000,7598.944000,EOR3 POC

39,3554.980000,4123.429000,7598.254000,EOR3 PT

40,3474.202000,4138.266000,7596.585000,EOR3 PC

41,3460.530000,4137.037000,7595.694000,EOR3 POC

42,3447.801000,4127.569000,7595.685000,EOR3 PT

43,3429.537000,4106.836000,7595.722000,EOR3 PC

44,3409.465000,4098.452000,7595.469000,EOR3 POC

45,3382.756000,4105.601000,7595.091000,EOR3 PT

46,3361.615000,4124.712000,7593.312000,EOR3

47,3387.770000,4135.513000,7595.224000,BLDGS
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48,3405.025000,4118.495000,7595.574000,BLDGS
49,3433.298000,4147.228000,7595.415000,BLDGS
50,3437.398000,4196.588000,7592.503000,EOR3
51,3474.994000,4159.305000,7595.447000,EOR3 PC
52,3482.659000,4151.988000,7595.960000,EOR3 POC
53,3490.096000,4149.263000,7596.415000,EOR3 PT
54,3551.238000,4135.854000,7597.521000,EOR3 PC
55,3577.878000,4122.437000,7598.692000,EOR3 POC
56,3603.411000,4091.156000,7599.418000,EOR3 PT
57,3615.492000,4061.476000,7599.741000,EOR3 PC
58,3620.402000,4056.572000,7599.525000,EOR3 POC
59,3625.984000,4059.508000,7599.584000,EOR3 PT
60,3627.008000,4060.528000,7599.427000,EOR3 PC
61,3642.650000,4073.714000,7598.575000,EOR3 POC
62,3656.391000,4083.325000,7597.481000,EOR3 PT
63,3719.756000,4124.384000,7590.387000,EOR3
64,3726.069000,4113.085000,7590.184000,EOR2
65,3791.231000,4157.937000,7582.978000,EOR2
66,3786.070000,4166.784000,7583.041000,EOR3
67,3098.793000,3678.474000,7578.957000,BS SW PIN
68,4072.640000,4366.705000,7573.982000,TP-ROCK
69,3609.125000,3906.901000,7599.989000,BS TP-ROAD
70,3786.089000,4166.738000,7582.997000,CHK
71,3823.759000,4195.204000,7580.534000,EOR3 PC
72,3829.137000,4187.246000,7580.556000,EOR2 PC
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73,3853.375000,4213.291000,7578.054000,EOR2 POC
75,3845.157000,4219.794000,7577.915000,EOR3 POC
77,3865.109000,4236.762000,7576.017000,EOR2 POC
78,3852.916000,4239.272000,7576.274000,EOR3 POC
79,3858.439000,4266.313000,7574.376000,EOR3 PT
80,3870.128000,4265.439000,7574.193000,EOR2 PT
81,3883.910000,4356.275000,7567.099000,EOR2 PC
82,3871.210000,4358.201000,7567.451000,EOR3 PC
83,3880.058000,4396.874000,7564.764000,EOR3 POC
84,3894.125000,4398.986000,7563.994000,EOR2 POC
85,3921.959000,4446.332000,7559.728000,EOR2 PT
86,3914.523000,4453.435000,7559.602000,EOR3 PT
87,3953.051000,4497.170000,7555.424000,EOR3
88,3961.106000,4488.771000,7555.928000,EOR2
89,4019.201000,4551.276000,7552.314000,EOR2
90,4010.571000,4560.509000,7551.224000,EOR3
91,4047.271000,4542.379000,7554.432000,BLDGS
92,4061.628000,4530.615000,7556.272000,BLDGS
93,4066.422000,4537.041000,7555.661000,BLDGS
94,4074.462000,4529.867000,7556.917000,BLDGS
95,4043.765000,4493.896000,7559.062000,BLDGS
96,4054.636000,4484.639000,7560.770000,BLDGS
97,4009.864000,4431.492000,7563.272000,BLDGS
98,3973.243000,4460.980000,7558.742000,BLDGS
99,3997.220000,4493.286000,7556.695000,BLDGS
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Teacher Supplement 2

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100,4015.391000,4478.070000,7558.883000,BLDGS
101,4035.086000,4500.828000,7557.890000,BLDGS
102,4020.803000,4512.580000,7556.041000,BLDGS
103,4047.051000,4542.002000,7554.526000,BLDGS
104,4228.858000,4573.390000,7562.185000,TOP**
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117,4092.860000,4358.006000,7575.537000,TOP**
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Teacher Supplement 2

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Teacher Supplement 2

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232,4186.436000,4799.897000,7533.379000,SHACK
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241,4072.634000,4366.702000,7573.966000,BS TP-ROCK
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Unit 4

Standard Symbols and Abbreviations

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 4–3
Answers to Assignment Sheets 4–7
Written Test 4–9
Answers to Written Test 4–21
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Student Components

Student Page

Objective Sheet 4–3
Information Sheet 4–5

Student Supplement

1—Abbreviations of Commonly Used Words in Civil Drafting 4–27

Assignment Sheets

1—Set Up a Map Legend 4–33
2—Locate and Identify Symbols and Features on a USGS Map 4–35

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Refer to MAVCC's publication, *Pipe Drafting*, Unit 6, for more in-depth information on pipe drafting symbols.
- Refer to MAVCC's publication, *Mechanical Drafting*, Unit 6, for more in-depth information on welding symbols.
- Use a topographic map of your local area to locate specific symbols used on the map.
- Have students find the abbreviations or symbols for the terms and definitions found in future units. This can be used as an assignment sheet.
- Using vendor catalogs, look up the templates that can be used in civil drafting. List vendor, template name, number, and scale.
- Daily, list a symbol or abbreviation on the chalkboard and have a mini quiz or contest on determining the correct feature or label these stand for.
- Interview a GIS operator about how they set up symbols.
- Refer to ANSI standards Y14.5 to review with students the standard line conventions for drafting.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- Brinker, Russell C. and Paul R. Wolf, *Elementary Surveying*, 9th ed. New Jersey: Prentice-Hall, Inc., 1998.
- Brown, Walter and Clois E. Kicklighter. *Drafting for Industry*. South Holland, IL: Goodheart-Willcox Company, Inc., 1995.
- *Definitions of Surveying and Associated Terms*. American Congress on Surveying and Mapping and the American Society of Civil Engineers. (out of print)
- *Glossaries of BLM Surveying and Mapping Terms*. Bureau of Land Management/U.S. Department of the Interior.
- Madsen, David and Terence Shumaker. *Civil Drafting Technology*, 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1997.
- Wirshing, Roy H. and James R. Wirshing. *Civil Engineering Drafting*. New York: Glencoe/McGraw-Hill, Inc., 1983, Imprint 1993.

Suggested Supplemental Resources

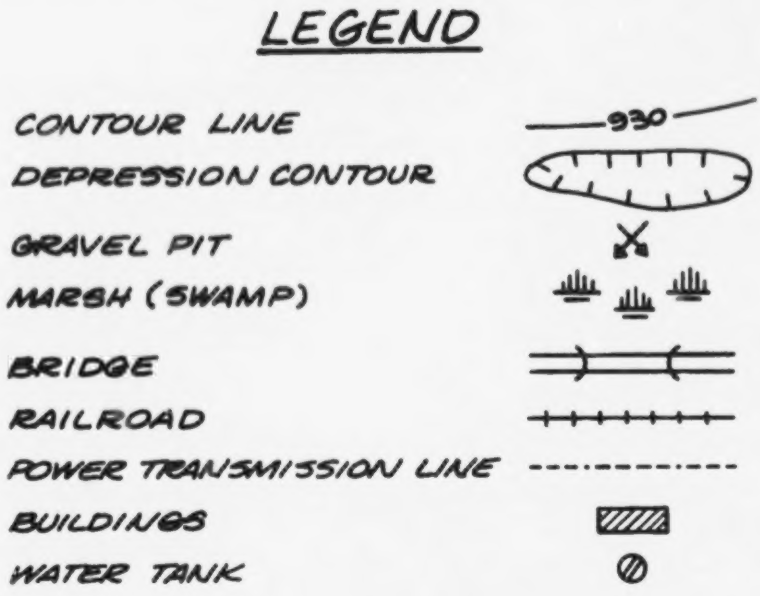
Print Media

- Sources for standardized symbols
  - Federal Board of Survey and Maps
  - National Oceanic and Atmospheric Administration (formerly U.S. Coast and Geodetic Survey)
  - Brochure of topographic map symbols available from U.S. Geological Survey, 1-800-USA-MAPS
  - U.S. Forest Service
  - Defense Mapping Agency (DMA)

Answers to Assignment Sheets

Assignment Sheet 1

Set Up a Map Legend


LEGEND
CONTOUR LINE
930
DEPRESSION CONTOUR
GRAVEL PIT
MARSH (SWAMP)
BRIDGE
RAILROAD
POWER TRANSMISSION LINE
BUILDINGS
WATER TANK

Assignment Sheet 2

Locate and Identify Symbols and Features on a USGS Map

1. Well symbol
2. Clay pit
3. Spot elevation
4. Index contour
5. Secondary road
6. Stream
7. Railroad
8. Building
9. Reservation boundary
10. Power transmission line
11. Unimproved road
12. Bench mark
13. Section line
14. Section contour
15. Gravel

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match terms related to standard symbols and abbreviations with their definitions.

1. Boundary
2. Cultural features
3. Geological
4. Hydrographic features
5. Legend
6. Map scale
7. Natural land features
8. Navigation
9. Planimetry
10. Symbol

_____ a. The structure and composition of the earth's crust

_____ b. Method of charting waters which affords a channel for useful commerce or travel

_____ c. Man-made features such as railroads, bridges, roads, and public utilities

_____ d. A diagram, design, letter, or abbreviation which by convention or reference to a legend is understood to represent a specific characteristic or object

_____ e. A description, explanation, table of symbols, and other information which is printed on a map or chart for better understanding and interpretation

_____ f. Showing the details of a map in plan view

_____ g. A line of demarcation between adjoining parcels of land

_____ h. Features on a map such as lakes, streams, terrain, and vegetation

_____ i. The relationship existing between a distance on a map and the corresponding distance on the earth

_____ j. Features along the shore and the submerged parts of bodies of water

Objective 2

List four types of symbols commonly used in civil drafting.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Written Test

Objective 3

Write the abbreviations for the following words used on public land surveys.

a. acres __________
b. auxiliary meander corner __________
c. boundary, boundaries __________
d. bearing tree __________
e. closing corner __________
f. chain, chains __________
g. corner, corners __________
h. correction __________
i. declination __________
j. distance __________
k. fractional (sec., etc.) __________
l. Greenwich __________
m. guide meridian __________
n. link, links __________
o. measurement __________
p. meridian __________
q. marked __________
r. mile corner __________
s. meander corner __________
t. mineral survey __________
u. point __________
v. principal meridian (P.M.) __________
w. range, ranges __________
x. range 1 west __________
y. standard corner __________
z. section, sections __________
aa. special meander corner __________
bb. standard parallel (S.P.) __________
cc. township, townships __________
dd. township 2 north __________
ee. U.S. location monument __________
ff. U.S. mineral monument __________
gg. witness corner __________

Objective 4

Write the abbreviations for the following words used on construction surveys.

a. left (x-sect. notes) __________
b. manhole __________
c. property line __________
d. power pole __________
e. pavement __________
f. right (x-sect. notes) __________
g. right-of-way __________
h. storm drain __________
i. subgrade __________
j. spring line __________
k. specifications __________
l. square __________
m. slope stake, side slope __________
n. standard __________
o. straight grade __________
p. cross-section __________
q. batterboards __________
r. building line __________
s. catch basin __________
t. center line of grade __________
u. center line __________
v. construction __________
w. cut __________
x. easement __________
y. fill __________
z. finish grade, Fin. Gr. __________
aa. fire hydrant __________
bb. fence line __________
cc. flow line (invert) __________
dd. finished surface __________
ee. grade change __________
ff. grade point __________
gg. grade rod (s.s. notes) __________

Objective 5

Write the abbreviations for the following words used on property surveys.

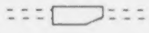
a. area ____________
b. curb face ____________
c. chiseled X cross ____________
d. cast iron ____________
e. diameter ____________
f. drive ____________
g. end of return ____________
h. existing ____________
i. hub and tack ____________
j. house connection sewer ____________
k. iron bolt (bar) ____________
l. iron pipe; iron pin ____________
m. lead and tack ____________
n. maximum ____________
o. minimum ____________
p. mean high water ____________
q. mean low low water ____________
r. mean low water ____________
s. monument ____________
t. number ____________
u. pipe; pin ____________
v. record ____________
w. street ____________
x. standard survey monument ____________
y. standard traverse monument ____________
z. two- X two-inch stake ____________
aa. cross cut in stone ____________
bb. yard ____________

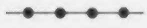
Objective 6

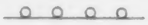
Match symbols used in surveying with their meanings.

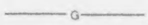
1.

2.

3. 

4. 

5. 

6. 

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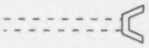
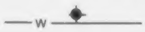
8. 

9. 

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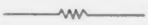
11. 

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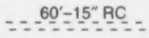
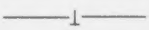
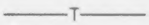
13.

14.

15. 

16. 

17. 

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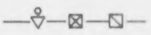
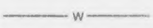
19.

20. 

21. 

_____ a. Power pole
_____ b. Fence, chain link
_____ c. Headwall
_____ d. Telephone line (buried)
_____ e. Traffic signal
_____ f. Chiseled monument
_____ g. Gas line
_____ h. Hydrant on water line
_____ i. Property line
_____ j. Telephone pole
_____ k. Water line
_____ l. Concrete monument
_____ m. Fence, wood w/posts
_____ n. Stake (or hub) with tack
_____ o. Telephone line (suspended)
_____ p. Guy wire
_____ q. Valves on water line
_____ r. Curb inlet
_____ s. Power line
_____ t. Storm sewer (length, size, type)
_____ u. Iron pipe

Written Test

Objective 7

Select true statements concerning factors that determine when an abbreviation should be used by placing an "X" in the blanks next to the true statements.

_____ a. Use an abbreviation when necessary to save time and space.

_____ b. Use an abbreviation only when the meaning is unquestionably clear to the intended reader.

_____ c. Use your own shortened versions of abbreviations as desired.

Objective 8

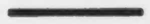
State two purposes of symbols on maps.

a. ______________________________

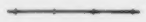
b. ______________________________

Objective 9

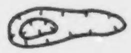
Identify the following USGS topographic map symbols.



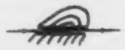
a. ____________________



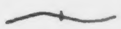
b. ____________________



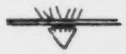
c. ____________________



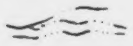
d. ____________________



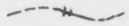
e. ____________________



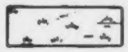
f. ____________________



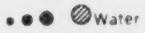
g. ____________________



h. ____________________

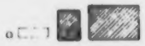


i. ____________________

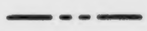


j. ____________________

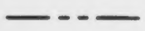
k. ____________________



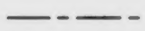
l. ____________________



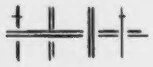
m. ____________________



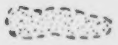
n. ____________________



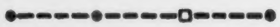
o. ____________________



p. ____________________

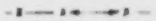


q. ____________________

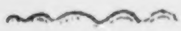


r. ____________________

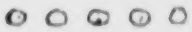
Objective 10 Identify the following other conventional topographic symbols.



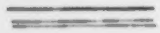
a. ____________________



b. ____________________



c. ____________________

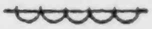


d. ____________________

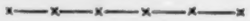
e. ____________________

f. ____________________

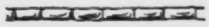
Objective 11 Identify the following boundary, fence, and track fixture symbols.



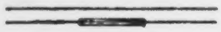
a. ____________________



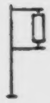
b. ____________________



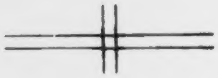
c. ____________________



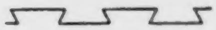
d. ____________________



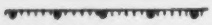
e. ____________________



f. ____________________



g. ____________________

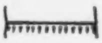


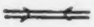
h. ____________________

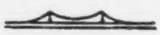
Written Test

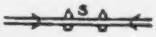
Objective 12

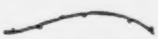
Match civil symbols with their meanings.

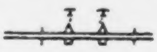
1. 

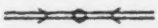
2. 

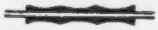
3. 

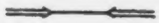
4. 

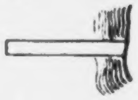
5. 

6. 

7. 

8. 

9. 

10. 

_____ a. Highway bridge (general symbol)

_____ b. Footbridge

_____ c. Steel truss bridge

_____ d. Suspension bridge

_____ e. Arch bridge

_____ f. Pontoon bridge

_____ g. Dam

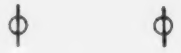
_____ h. Telephone line

_____ i. Highway drawbridge

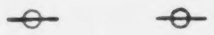
_____ j. Pier

Objective 13

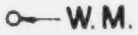
Identify the following utility and service symbols.



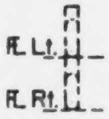
a. ______________________



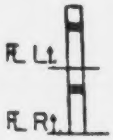
b. ______________________



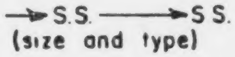
c. ______________________



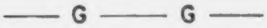
d. ______________________



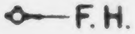
e. ______________________


S.S.
S.S.
(size and type)

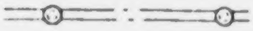
f. ______________________



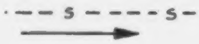
g. ______________________



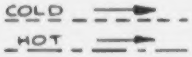
h. ______________________



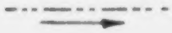
i. ______________________



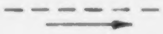
j. ______________________



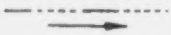
k. ______________________



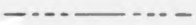
l. ______________________



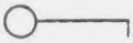
m. ______________________



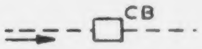
n. ______________________



o. ______________________



p. ______________________

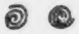


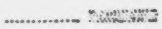
q. ______________________

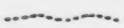
Written Test

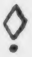
Objective 14

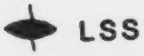
Match hydrographic and navigation symbols with the correct meanings.

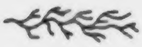
1. 

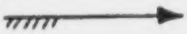
2. 

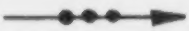
3. 

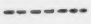
4. 

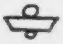
5. 

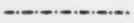
6. 

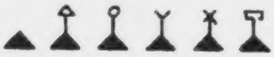
7. 

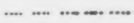
8. 

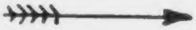
9. 

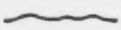
10. 

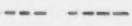
11. 

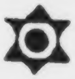
12. 

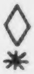
13. 

14. 

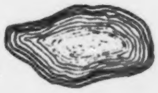
15. 

16. 

17. 

18. 

19

20. 

_____ a. Non-tidal current

_____ b. Tidal currents flood

_____ c. Tidal currents ebb 3rd hour

_____ d. Surveyed shore line

_____ e. Unsurveyed shore line

_____ f. Kelp or eel grass

_____ g. Life saving station

_____ h. Lighthouse

_____ i. General or red buoy

_____ j. Lighted buoy

_____ k. Lighted beacon

_____ l. Not lighted beacon

_____ m. Whirlpools and eddies

_____ n. Pond

_____ o. 1 fathom or 6′ line

_____ p. 4 fathom line

_____ q. 10 fathom line

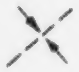
_____ r. Mooring buoy

_____ s. 100 fathom line

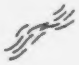
_____ t. 400 fathom line

Objective 15

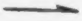
Match geological structure symbols with their correct meanings.

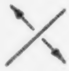
1. 

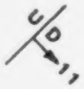
2.

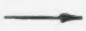
3. 

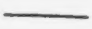
4.

5. 

6. 

7. 

8. 

9. 

10.

_____ a. Direction

_____ b. Altitude

_____ c. Horizontal beds

_____ d. Horizontal cleavage

_____ e. Horizontal joint plane

_____ f. Axis of anticline

_____ g. Axis of syncline

_____ h. Known fault

_____ i. Shear zone

_____ j. Normal fault

Written Test

Objective 16

Complete the following chart of oil and gas symbols and their meanings.

Location, rig or drilling well	a. ______	Dry hole	f. ______
Oil well	b. ______	Dry hole, abandoned	g. ______
Oil well, abandoned	c. ______	Dry hole with showing of oil, number 8	h. ______
d. ______________	●	i. ______________	☼
e. ______________	●	j. ______________	⊖

Objective 17

Draw three examples of north arrow symbols in the space below.

Objective 18

Select true statements concerning general rules for drawing map symbols by placing an "X" in the blanks next to the true statements.

_____ a. Should be difficult to read so only the engineer can understand

_____ b. Should conform to the general design and purpose of the drawing

_____ c. Do not follow standard formats

_____ d. Should assume as much as possible the form of the actual object it represents

_____ e. Should be used excessively, even if they crowd the map

_____ f. Number of symbols included on a map is limited by the scale of the map

_____ g. On large scale maps, all symbols are drawn much larger

_____ h. Prominence of a symbol over another is achieved by variation in the shading and color usage

_____ i. Symbols repeated on a map may be drawn differently for variety

_____ j. The base of a symbol (such as for grass) should be drawn parallel to the nearest roadway or stream

_____ k. Good rule to follow in proportioning a map would be to draw the important symbols first and work toward the least important features.

Objective 19

List three methods used in drawing symbols.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 20

Match color codes with their corresponding map symbols.

1. Red
2. Black
3. Yellow
4. Blue
5. Gray
6. Brown
7. Purple
8. Green

_____ a. Water features

_____ b. Vegetation

_____ c. Cultural features, boundaries, lettering and notations

_____ d. Contours, sand, washes, and topographic relief

_____ e. Shading and hatch marks

_____ f. Office revisions from aerial photographs

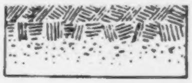
_____ g. Additional boundaries and distributional tones

_____ h. Important roads, public land and land grants, subdivisions, and field lines

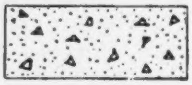
Written Test

Objective 21

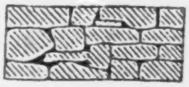
Identify the following common material symbols used in structural and architectural drawings.



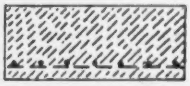
a. __________________



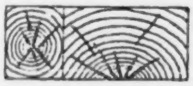
b. __________________



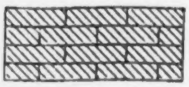
c. __________________



d. __________________



e. __________________



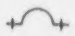
f. __________________

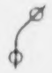
Objective 22

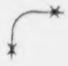
Complete the following chart of standard symbols for pipe fittings by either drawing the required symbols or by stating the type of symbol shown **and** its method of connection.

a. Bell & spigot cap __________

b. Flanged, straight size cross __________

c. __________________ 

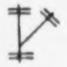
d. __________________ 

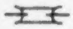
e. __________________ 

f. Screwed, double branch elbow __________

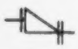
g. Screwed street elbow __________

h. Flanged, long radius elbow __________

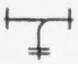
i. __________________ 

j. __________________ 

k. Welded concentric reducer __________

l. __________________ 

m. Bell & spigot straight size tee __________

n. __________________ 

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 3
b. 8
c. 2
d. 10
e. 5
f. 9
g. 1
h. 7
i. 6
j. 4

Objective 2

Any four of the following:

a. Map symbols
b. Drawing symbols
c. Labels in the form of abbreviations
d. Pipe symbols
e. Weldment symbols
f. Utility symbols
g. Material symbols
h. Oil and gas symbols
i. GIS symbols

Objective 3

a. ac
b. AMC
c. bdy., bdys.
d. BT
e. CC
f. ch, chs
g. cor., cors.
h. corr.
i. decl.
j. dist.
k. frac.
l. Gr.
m. G.M.
n. lk, lks
o. meas.
p. mer.
q. mkd.
r. Mi. Cor.
s. MC
t. M.S.
u. pt.
v. Prin. Mer.
w. R, Rs
x. R 1 W
y. SC
z. Sec., Secs.
aa. SMC
bb. Stan. Par.
cc. T, Tp, Tps
dd. T 2 N
ee. U.S.L.M.
ff. U.S.M.M.
gg. WC

Objective 4

a. L
b. M.H.
c. ⅊
d. P. P.
e. pvmt.
f. R
g. R/W
h. S.D.
i. S.G.
j. S.L.
k. Spec
l. Sq.
m. s.s.
n. Std.
o. Str. Gr.
p. X-sect.
q. b.b.
r. B.L.
s. C.B.
t. C.G.

Answers to Written Test

u. CL
v. const.
w. C
x. esmt.
y. F
z. F.G.
aa. F.H.
bb. FL
cc. F.L.
dd. F.S.
ee. G.C.
ff. G.P.
gg. G.R.

Objective 5

a. A
b. C.F.
c. ch "X"
d. C.[illegible].
e. diam.
f. Dr.
g. ER
h. Ex.
i. H&T
j. H.C.
k. I.B.
l. I.P.
m. L&T
n. max.
o. min.
p. M.H.W.
q. M.L.L.W.
r. M.L.W.
s. Mon.
t. No.
u. P
v. Rec.
w. St.
x. Std. Surv. Mon.
y. Std. Trav. Mon.
z. 2" x 2"
aa. X
bb. yd.

Objective 6

a. 12
b. 4
c. 8
d. 16
e. 19
f. 1
g. 6
h. 9
i. 13
j. 18
k. 21
l. 2
m. 5
n. 14
o. 17
p. 7
q. 20
r. 3
s. 11
t. 15
u. 10

Objective 7

a, b

Objective 8

a. To represent the location and identity of land features that are generally too large to be shown in detail on a map
b. To help keep information on a map to a minimum and thereby avoid cluttering

Objective 9

a. Primary highway, hard surface
b. Single track railroad
c. Depression contours
d. Cut
e. Small falls
f. Fill
g. Intermittent streams
h. Small rapids

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i. Marsh (swamp)
j. Water tank
k. Church
l. Buildings
m. National boundary line
n. State boundary line
o. County, parish, or municipal boundary line
p. Road overpass and underpass
q. Dry lake bed
r. Power transmission line

Objective 10

a. Fence line
b. Edge of wooded area
c. Trees
d. Curb and gutter (proposed)
e. School
f. Manhole

Objective 11

a. Track pan
b. Barbed wire fence
c. Stone fence
d. Single car retarder
e. Mail crane
f. Crossing
g. Rail fence
h. Picket fence

Objective 12

a. 2
b. 9
c. 4
d. 3
e. 8
f. 6
g. 1
h. 5
i. 7
j. 10

Objective 13

a. Overhead power
b. Overhead telephone
c. Water meter
d. Existing 90° pipe
e. New 90° box
f. Sanitary sewer
g. Gas line
h. Fire hydrant
i. Storm sewer and manhole
j. Sewer line
k. Water pipes
l. Compressed air pipe
m. Condensate pipe
n. Oil pipe
o. Refrigerant pipe
p. Water column
q. Catch basin

Answers to Written Test

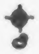
Objective 14

a.	14	k.	19
b.	7	l.	12
c.	8	m.	1
d.	15	n.	20
e.	3	o.	2
f.	6	p.	13
g.	5	q.	11
h.	17	r.	10
i.	4	s.	9
j.	18	t.	16

Objective 15

a.	5	f.	6
b.	8	g.	1
c.	2	h.	9
d.	10	i.	3
e.	4	j.	7

Objective 16

a.	○	f.	
b.	●	g.	
c.		h.	
d.	Small oil well	i.	Gas well
e.	Small oil well, abandoned	j.	Salt well

Objective 17

Evaluated to the satisfaction of the instructor

Objective 18

b, d, f, k

Objective 19

Any three of the following:

a. Freehand, such as woods, streams, material symbols
b. Template for specific mapping symbols
c. Stick up sheets
d. Pressure-sensitive transfers
e. CAD

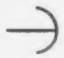
Objective 20

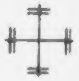
a.	4	e.	5
b.	8	f.	7
c.	2	g.	3
d.	6	h.	1

Objective 21

a.	Earth	d.	Concrete reinforced with bars
b.	Plain concrete	e.	Finish wood
c.	Rubble stone	f.	Brick (face or common)

Objective 22

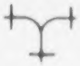
a. 

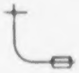
b. 

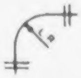
c. Screwed crossover

d. Soldered 45° elbow

e. Welded 90° elbow

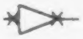
f. 

g. 

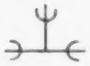
h. 

i. Flanged lateral

j. Bell & spigot expansion joint

k. 

l. Flanged eccentric reducer

m. 

n. Screwed, single sweep tee

Prerequisites:
Unit 1

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 and 2, and Student Supplement 1.

☐ 4. **Study** Information Sheet, Objectives 3 through 22.

☐ 5. **Do** Assignment Sheet 1, "Set Up a Map Legend."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat steps 4 through 6.

☐ 7. **Do** Assignment Sheet 2, "Locate and Identify Symbols and Features on a USGS Map."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, repeat steps 7 and 8.

☐ 9. **Check** With instructor for any additional assignments to be completed.

☐ 10. **Do** Additional assignments listed below.

____

____

____

Learning Activities Sheet

☐ 11. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 12. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Unit 5

Map Projections, Reference Systems, and Legal Land Descriptions

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 5–3

Answers to Assignment Sheets 5–7

Written Test 5–11

Answers to Written Test 5–21

Learning Activities Sheet 5–25

Transparency Masters

- 1—U.S. Public Land Survey System 5–29
- 2—Sample Subdivision of a Section 5–31
- 3—Lot and Block Description 5–33
- 4—Meridians and Parallels 5–35
- 5—Typical Metes and Bounds Description 5–37
- 6—Reference System Spacing for State Plane Coordinates 5–39

Student Components

Student Page

Objective Sheet 5–3

Information Sheet 5–5

Student Supplements

- 1—Principal Meridians and Base Lines 5–21
- 2—U.S. Public Land Survey System 5–23
- 3—Lot and Block Description 5–25
- 4—Typical Metes and Bounds Descriptions 5–27
- 5—Sample Plat 5–29
- 6—State Plane Coordinate Grid Systems 5–31
- 7—Metric Coordinate Reader 5–33

Assignment Sheets

- 1—Answer Questions Based on the U.S. Public Land Survey System 5–35
- 2—Write and Locate Descriptions for the Subdivision of a Section 5–37
- 3—Write a Lot and Block Description 5–43
- 4—Identify Components Used to Develop a Plat 5–45
- 5—Identify Geographic Coordinates on a USGS Quadrangle Map 5–47
- 6—Scale on a UTM Grid 5–49

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Visit the local county courthouse and obtain a copy of the plat for the location of the school.
- Arrange a field trip with a local surveyor to observe a surveying team in the field.
- Obtain a copy of the local codes concerning easements, setbacks, and road right-of-ways.
- Obtain a USGS 7.5 minute quadrangle map of your local area and locate by township, range, and section many local landmarks.
- Provide students with a copy of the USGS 7.5 minute quadrangle map for use in Assignment Sheets 1 and 5.
- Using Unit 4, Standard Symbols and Abbreviations, as a reference, match symbols and abbreviations to terms in this unit.
- Obtain plat maps from a local surveyor and have students identify different types of land descriptions.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- Colley, Barbara C. *Practical Manual of Land Development*, 3rd ed. New York: McGraw-Hill, Inc., 1998.
- *Definitions of Surveying and Associated Terms.* American Congress on Surveying and Mapping and the American Society of Civil Engineers. (Out of print).

- *Glossaries of BLM Surveying and Mapping Terms*, 2nd ed. Bureau of Land Management/U.S. Department of the Interior.
- Hoag, John S. *Fundamentals of Land Measurement.* Chicago, IL: Chicago Title Insurance Company.
- Madsen, David and Terence Shumaker. *Civil Drafting Technology*, 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc. 1997.
- Thompson, Morris M. *Maps for America*, 3rd ed. ISGS, United States Department of the Interior, 1987. (Out of print)
- Wattles, Gurdon. *Survey Drafting*, 2nd ed. Orange, CA: Gurdon H. Wattles Publications, 1981.

Suggested Supplemental Resources

Print Media

- Brinker, Russell C. and Paul R. Wolf. *Elementary Surveying*, 9th ed. New Jersey: Prentice-Hall, Inc.,1998.
- Kavanaugh, Barry and Bird Glenn, S. J. *Surveying: Principles and Applications*, 5th ed. Prentice-Hall, 2000.

Answers to Assignment Sheets

Assignment Sheet 1

Answer Questions Based on the U.S. Public Land Survey System

Student performance should be evaluated according to the criteria listed on the assignment sheet. Answers will vary depending on which USGS 7.5 minute quadrangle map is used.

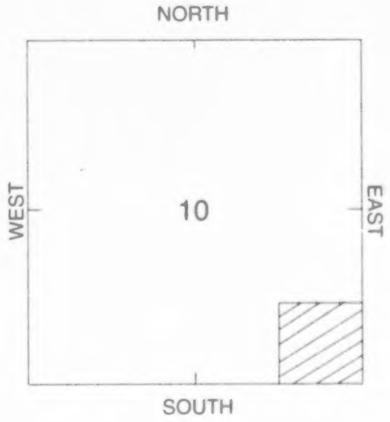
Assignment Sheet 2

Write and Locate Descriptions for the Subdivision of a Section

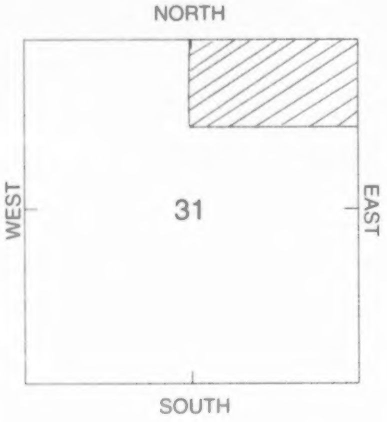
Part 1

a. NW 1/4, NW 1/4, SECT 10 (40 acres)
b. S 1/2, NE 1/4, SECT 36 (80 acres)
c. N 1/2, SW 1/4, SE 1/4, SECT 9 (80 acres)
d. E 1/2, NW 1/4, NE 1/4, SECT 2 (20 acres)
e. SW 1/4 AND N 1/2, SE 1/4, SECT 15 (240 acres)
f. N 1/2, NE 1/4, NE 1/4, SECT 20 (20 acres)

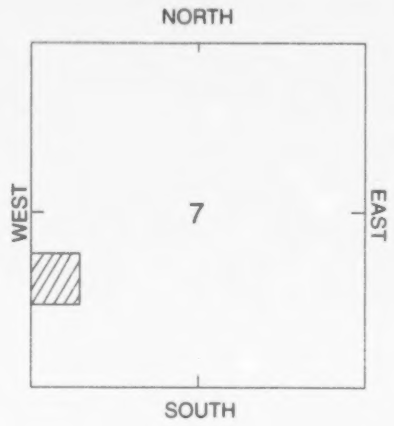
Part 2



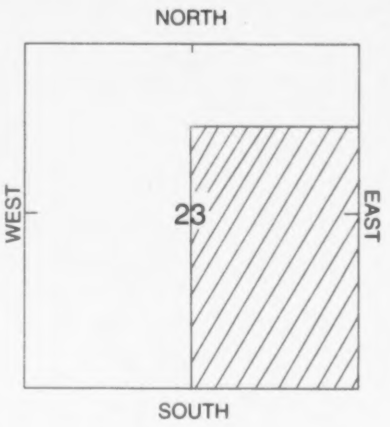
a. 40 acres



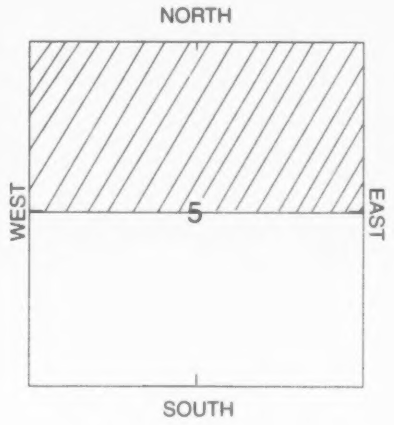
b. 80 acres


NORTH
WEST
7
EAST
SOUTH

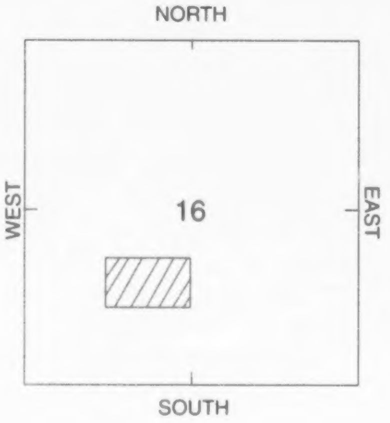
c. 10 acres


NORTH
WEST
23
EAST
SOUTH

d. 240 acres


NORTH
WEST
5
EAST
SOUTH

e. 320 acres


NORTH
WEST
16
EAST
SOUTH

f. 20 acres

Assignment Sheet 3

Write a Lot and Block Description

1. Lot 3, Block 1, Breckenridge Industrial Park, City of Breckenridge, Wilkin County, State of Minnesota

2. Lot 7, Block 4, Breckenridge Industrial Park, City of Breckenridge, Wilkin County, State of Minnesota

Assignment Sheet 4

Identify Components Used to Develop a Plat

Student performance should be evaluated using answer key provided by instructor.

Assignment Sheet 5

Identify Geographic Coordinates on a USGS Quadrangle Map

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 6

Scale on a UTM Grid

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match terms related to map projections, reference systems, and legal land descriptions with their definitions. Definitions continue on the next page.

1. Bearing
2. Course
3. Easement
4. Elevation
5. Longitude
6. Lot and block
7. Meridian
8. Monument
9. Point of beginning
10. Prime meridian
11. Principal meridian
12. Subdivision survey
13. Azimuth
14. Base line
15. Benchmark
16. Central meridian
17. Chain
18. Deed
19. Geodetic survey
20. Land survey
21. Latitude
22. Legal description
23. Magnetic meridian
24. Plot plan
25. Subdivision (real estate)
26. Subdivision (USPLS)
27. Bounds
28. Coordinates
29. Datum
30. Metes
31. Plat
32. Public domain
33. Traverse
34. Triangulation
35. Triangulation station

_____ a. Arc distance measured in degrees east and west from the prime meridian

_____ b. In surveying, the direction of a line with reference to a meridian

_____ c. The meridian of longitude 0°; the meridian of Greenwich, England

_____ d. An interest or right in land owned by another that entitles its holder to a specific limited use

_____ e. A meridian established as a basis for establishing a reference line for the organization of the public land survey system

_____ f. Line of longitude that runs straight north and south

_____ g. The direction of a line with respect to the quadrants of a compass starting from north or south

_____ h. A type of land survey in which the legal boundaries of an area are located and the area is divided into parcels of lots, streets, right-of ways, etc.

_____ i. Vertical distance from a datum (generally mean sea level) to a point or object on the earth's surface

_____ j. Permanent object that marks established points

_____ k. Established corner from which measurements are started

_____ l. A method that describes land by referring to a recorded plat, lot numbers, county, and state

_____ m. A survey that locates property corners and boundary lines; usually closed with a traverse

_____ n. An unimproved tract of land surveyed and divided into lots for purposes of sale

_____ o. The subdivision of a township such as sections, township and range numbers, and the description of the principal meridian to which referred

_____ p. A principal parallel that runs straight east and west and that is used in establishing the public land survey system of land description

_____ q. Arc distance measured in degrees north and south of the equator

_____ r. Legal document which specifies the ownership of the land

_____ s. A written statement recognized by law as a definite location of a tract of land by reference to a survey, recorded map, or adjoining property

_____ t. A plan showing where a building is to be placed with proposed utility locations; not recorded with the county

_____ u. A measurement tool composed of links, originally 66 feet in length

_____ v. A horizontal direction measured in degrees from 0 to 360, usually measured from the north

_____ w. A survey of large areas of land in which corrections are made for the curvature of the earth's surface

_____ x. The line of longitude at the center of a projection

_____ y. The direction a free magnet responds to the earth's magnetic pull

_____ z. A relatively permanent material bearing a mark of elevation whose elevation is above or below the adopted datum

_____ aa. Linear and (or) angular quantities that designate the position of a point in relation to a given reference frame

_____ bb. A map of a piece of land recorded in the county clerk and recorder's office

_____ cc. To measure or to assign by measure, as in the measurement of property lines expressed in units of feet, yards, or rods

_____ dd. Monuments which define the boundary or limit of property

_____ ee. Any numerical or geometrical quantity or set of such quantities which may serve as a reference or base for other quantities

_____ ff. A method of surveying in which the stations are points on the ground at the vertices of a chain or network of triangles

_____ gg. A marked and/or described point whose position has been determined by triangulation

_____ hh. Any or all of those areas of land ceded to the federal government by the original states and to such other lands as were later acquired by treaty, purchase, or cession and are disposed of only under the authority of Congress

_____ ii. In surveying, a sequence of lengths and directions of lines between points on the earth, obtained by field measurements and used to determine the positions of points through use of trigonometric computation

Objective 2

Define the concepts that are fundamental to map projections and reference systems.

a. Map projection— ____

____

b. Graticule— ____

____

c. Grid— ____

____

Objective 3

Select true statements concerning factors in the selection of a map projection by placing an "X" in the blanks next to the true statements.

_____ a. The distances between two points on the earth should be correctly represented on the map

_____ b. Any shape on the earth must be represented truly on the map

_____ c. The azimuths from point to point on the earth may be any direction on the map

_____ d. Any area on the earth's surface can be represented by a modified area on the map

Written Test

Objective 4

Match projections used by the USGS with their definitions.

1. Albers equal area projection
2. Lambert and Transverse Mercator
3. Lambert conformal conic projection
4. Universal Transverse Mercator Projection

_____ a. Standard parallels at 29.5° and 45.5°; state base maps at 1:2,500,000 scale

_____ b. Standard parallels at 33° and 45°; state base map at 1:500,000 scale

_____ c. 1:250,000 scale series, 1:100,000 scale series, and Alaska 1:63,360 scale series

_____ d. State coordinate systems (15′ and 7.5 minute series)

Objective 5

Match methods of legal land descriptions with their definitions.

1. U.S. public land survey system
2. Lot and block description
3. Metes and bounds survey
4. State plane coordinates systems

_____ a. A survey of irregularly-shaped tract of land, not conforming to the rectangular system of survey

_____ b. A system inaugurated by the Continental Congress on May 20, 1785, for the survey of the public lands of the United States. Its distinguishing characteristic is that in the main, and in all cases where practical, its units are in rectangular form

_____ c. The systems established by the U.S. Coast and Geodetic Survey, one for each state in the union, used for defining positions of geodetic stations in terms of plane-rectangular (X and Y) coordinates

_____ d. A method of describing land by referring to a recorded plat, the lot number, the county, and state

Objective 6

Select true statements concerning coordinate systems by placing an "X" in the blanks next to the true statements.

_____ a. Coordinates are numbers that represent distances east and west of a reference point.

_____ b. Coordinate points can be real or imagined.

_____ c. Coordinate systems employ trigonometric relationships between points to determine distances and bearings exactly.

_____ d. Coordinate systems are not used to facilitate the location of property corners.

Objective 7

Complete the following statements concerning the U.S. public land survey (USPLS) system by circling the correct answers.

a. There are (**25, 35**) principal meridians.

b. The principal meridian is fixed by a (**longitudinal, latitudinal**) reading.

c. There are (**32, 50**) base lines.

d. (**Range lines, Township lines**) are east-west lines at six mile intervals parallel to the base line.

e. (**Range lines, Township lines**) are north-south lines at six mile intervals parallel to the principal meridian.

f. The Congressional act in 1796 directed each township to be subdivided into (**24, 36**) sections.

g. Each section measures approximately (**1, 24**) square mile(s).

h. The sections in each township are numbered consecutively with #1 in the (**southeast, northeast**) corner.

i. (**Irregular, Fractional**) sections are expected in counties bordering oceans, lakes, and streams.

Objective 8

Complete the following statements concerning the subdivision of a section by filling in the blanks with the correct words.

a. In 1800 Congress directed that a section could be subdivided in ________________ and ________________ halves (320 acres each).

b. In 1805 Congress directed further subdivision into ________________ sections and the monumenting of all of those section corners.

c. At later dates Congress directed further subdivision of the section into ________________ sections.

d. This subdivision of ________________ acres is the smallest statutory division of regular sections.

e. Legal descriptions of land which follow the regular subdivision of a regular section must include the section, township, and ________________.

f. A complete description always begins with the ________________ division.

Written Test

Objective 9

Complete statements concerning lot and block descriptions by circling the correct answers.

a. Lot and blocks describe (**subdivision boundaries, small units of property in a subdivision**).

b. A legal lot and block must be filed with the (**county, state**) as part of a plat.

c. Each block is (**numbered, lettered**) consecutively.

d. Each lot carries a (**number, letter**) shown in consecutive order within the block.

e. A (**lot, block, plat**) is captioned with the legal description.

f. Advantage of lot and block description is (**it shows all lots in relationship to other parcels of land, it is useful for irregularly shaped land**).

Objective 10

Select true statements concerning metes and bounds descriptions by placing an "X" in the blanks next to the true statements.

_____ a. Is the newest manner of describing land

_____ b. Is the method employed for demarcation of tracts of land in the original thirteen states

_____ c. A method to describe irregularly shaped parcels of land that are not part of a recorded plat

_____ d. Description may begin at any point

_____ e. Begins at some point in the boundary of the tract and then recites the courses (directions) and distances from point to point entirely around the tract

_____ f. All bounds are listed in rational order and referenced to a chart by bearing, distance, and monuments.

_____ g. The description need not close.

_____ h. A plat cannot be drawn from a metes and bounds description .

Objective 11

a. List five components used to develop a plat.

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

5) ______________________________

b. If part of public lands, list two additional components used.

1) ______________________________

2) ______________________________

Objective 12

Complete the following statements concerning state plane coordinates by circling the correct answers.

a. Was established in (**1933, 1953**) by the U.S. Coast and Geodetic Survey

b. Uses a (**circular, rectangular**) grid designed to fit the curved shape of the earth to a plane surface with as little distortion as possible

c. Is used for defining positions of (**coastal, geodetic**) stations in terms of plane rectangular (X and Y) coordinates

d. (**Many, All**) states have established by law a state plane coordinate system in either Lambert projection or the transverse Mercator projection with one or more zones.

e. Lambert and Mercator grid systems each select (**one, ten**) true meridian(s).

f. All north-south lines of the grids are drawn (**parallel, perpendicular**) to the central meridian.

g. The (**Lambert, Mercator**) projection grid assigns an X value at the central meridian (Y axis) of 2,000,000 ft and a Y value at the X axis of "0" ft.

h. The (**Lambert, Mercator**) projection grid assigns an X value at the central meridian (Y axis) of 500,000 ft and a Y value at the X axis of "0" ft.

i. The transverse Mercator projection was limited to 158 miles (approx.) in the (**north-south, east-west**) direction to minimize distortion.

j. The Lambert projection was limited to 158 miles (approx.) in the (**north-south, east-west**) width to minimize distortion.

k. Coordinates are based on (**sea level, 100 feet above sea level**).

l. Is used extensively for photogrammetric plotting and (**manual, electronic**) surveying

Written Test

Objective 13

Match the common legal aspects of land acquisition with their correct definitions.

1. Adverse possession
2. Eminent domain
3. Acquiescence of possession
4. Riparian rights

_____ a. 1) Two adjoining property owners agree to a common boundary that does not follow the original surveyed line.

2) Area in question must be used exclusively and openly by respective property owner for at least 20 years.

3) There must be no disagreement between the two parties as to appropriateness of the line during the statutory period.

4) There must be a physical demarcation such as a fence between the two properties.

_____ b. The following basic elements must be present for a period of 10-20 years: possession is against wishes of owner and without consent, possession is open, actual improvements are present, and possession must be exclusive, continuous, and hostile to the rightful owner.

_____ c. The right of a public authority to take property for public use; requisites include

1) A clear statement of necessity is made.
2) The acquisition is in the public interest.
3) No substitute property will do.
4) Reimbursement will be at fair market value to the owner.

_____ d. Refers to those rights of a property owner of land that borders on a water body

Objective 14

List the six types of boundary classifications.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

Objective 15

Arrange in order the precedence for boundary rank of types of boundary units by numbering them from 1-5 in the blanks provided.

_____ a. County subdivisions, civil townships, or towns

_____ b. State, commonwealth, and territory

_____ c. Incorporated places not having the status of a county

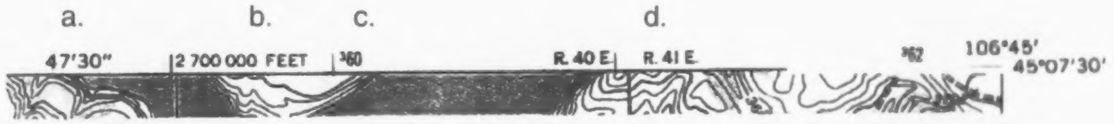
_____ d. National

_____ e. County (parish, borough, or municipality)

Objective 16

Identify types of geographic coordinates found on a USGS quadrangle map.

a. __________ b. __________ c. __________ d. __________



Objective 17

Select true statements concerning the BLM Land Information System (LIS) by placing an "X" in the blanks next to the true statements.

_____ a. LIS is comprised of two separate functions: automated land and mineral record system (ALMRS) and automated resource data (ARD).

_____ b. ARD includes information about municipalities.

_____ c. One of the objectives of LIS is to reduce the cost of land management through a computerized data base that streamlines responses to land and mineral inquiries.

_____ d. GCDB stands for Global Cartographic Data Bank.

_____ e. GCDB is a digital layer of information on the public land survey system.

_____ f. GCDB will include geographic coordinates of all Public Land Survey System (PLSS) corners.

_____ g. GCDB will list all the names of surveyors who set the PLSS corners.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 5
b. 2
c. 10
d. 3
e. 11
f. 7
g. 1
h. 12
i. 4
j. 8
k. 9
l. 6
m. 20
n. 25
o. 26
p. 14
q. 21
r. 18
s. 22
t. 24
u 17
v. 13
w. 19
x. 16
y. 23
z. 15
aa. 28
bb. 31
cc. 30
dd. 27
ee. 29
ff. 34
gg. 35
hh. 32
ii. 33

Objective 2

a. Map projection—A system to portray all or part of the round earth on a plane surface

b. Graticule—A network of lines or ticks representing the geographic parallels and meridians for the map projection

c. Grid—Two sets of parallel lines intersecting at right angles, forming a rectangular Cartesian coordinate system superimposed on a map projection

Objective 3

a, b

Objective 4

a. 1
b. 3
c. 4
d. 2

Objective 5

a. 3
b. 1
c. 4
d. 2

Objective 6

b, c

Objective 7

a. 35
b. Longitudinal
c. 32
d. Township lines
e. Range lines
f. 36
g. 1
h. northeast
i. Fractional

Answers to Written Test

Objective 8

a. east, west
b. quarter
c. quarter-quarter
d. 40
e. range
f. smallest

Objective 9

a. small units on property in a subdivision
b. county
c. numbered
d. number
e. plat
f. it shows all lots in relationship to other parcels of land

Objective 10

b, c, e, f

Objective 11

a. Any five of the following:

  1) City name
  2) County name
  3) State name
  4) Lot or parcel number, letter, or name
  5) Name or number of the map
  6) Point of beginning
  7) Bearings/azimuth and distances
  8) Monuments

b. Any two of the following:

  1) Section number
  2) Township number
  3) Range number
  4) Meridian

Objective 12

a. 1933
b. rectangular
c. geodetic
d. All
e. one
f. parallel
g. Lambert
h. Mercator
i. east-west
j. north-south
k. sea level
l. electronic

Answers to Written Test

Objective 13

a. 3
b. 1
c. 2
d. 4

Objective 14

a. International boundaries
b. State boundaries
c. Civil boundaries within a state
d. Incorporated areas
e. Corporate boundaries
f. Land grant and public land survey lines

Objective 15

a. 4
b. 2
c. 5
d. 1
e. 3

Objective 16

a. Longitude
b. State plane coordinate
c. UTM
d. Public Land System

Objective 17

a, c, e, f, g

Unit 5

Map Projections, Reference Systems, and Legal Land Descriptions

Prerequisites:
Units 1, 2,
and 4

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1–7, and Student Supplements 1 and 2.

☐ 4. **Do** Assignment Sheet 1, "Answer Questions Based on the U.S. Public Land Survey System."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat steps 1–5.

☐ 6. **Study** Information Sheet, Objective 8.

☐ 7. **Do** Assignment Sheet 2, "Write and Locate Descriptions for the Subdivision of a Section."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, repeat steps 6 through 8.

☐ 9. **Study** Information Sheet, Objective 9, and Student Supplement 3.

☐ 10. **Do** Assignment Sheet 3, "Write a Lot and Block Description."

Learning Activities Sheet

☐ 11. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 12. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 9-11.

☐ 12. **Study** Information Sheet, Objectives 10 and 11, and Student Supplements 4 and 5.

☐ 13. **Do** Assignment Sheet 4, "Identify Components Used to Develop a Plat."

☐ 14. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, repeat steps 12-14.

☐ 15. **Study** Information Sheet, Objectives 12-17, and Student Supplements 6 and 7.

☐ 16. **Do** Assignment Sheet 5, "Identify Geographic Coordinates on a USGS Quadrangle Map."

☐ 17. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, repeat steps 15-17.

☐ 18. **Do** Assignment Sheet 6, "Scale on a UTM Grid."

☐ 19. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, repeat steps 18 and 19.

☐ 20. **Check** With instructor for any additional assignments to be completed.

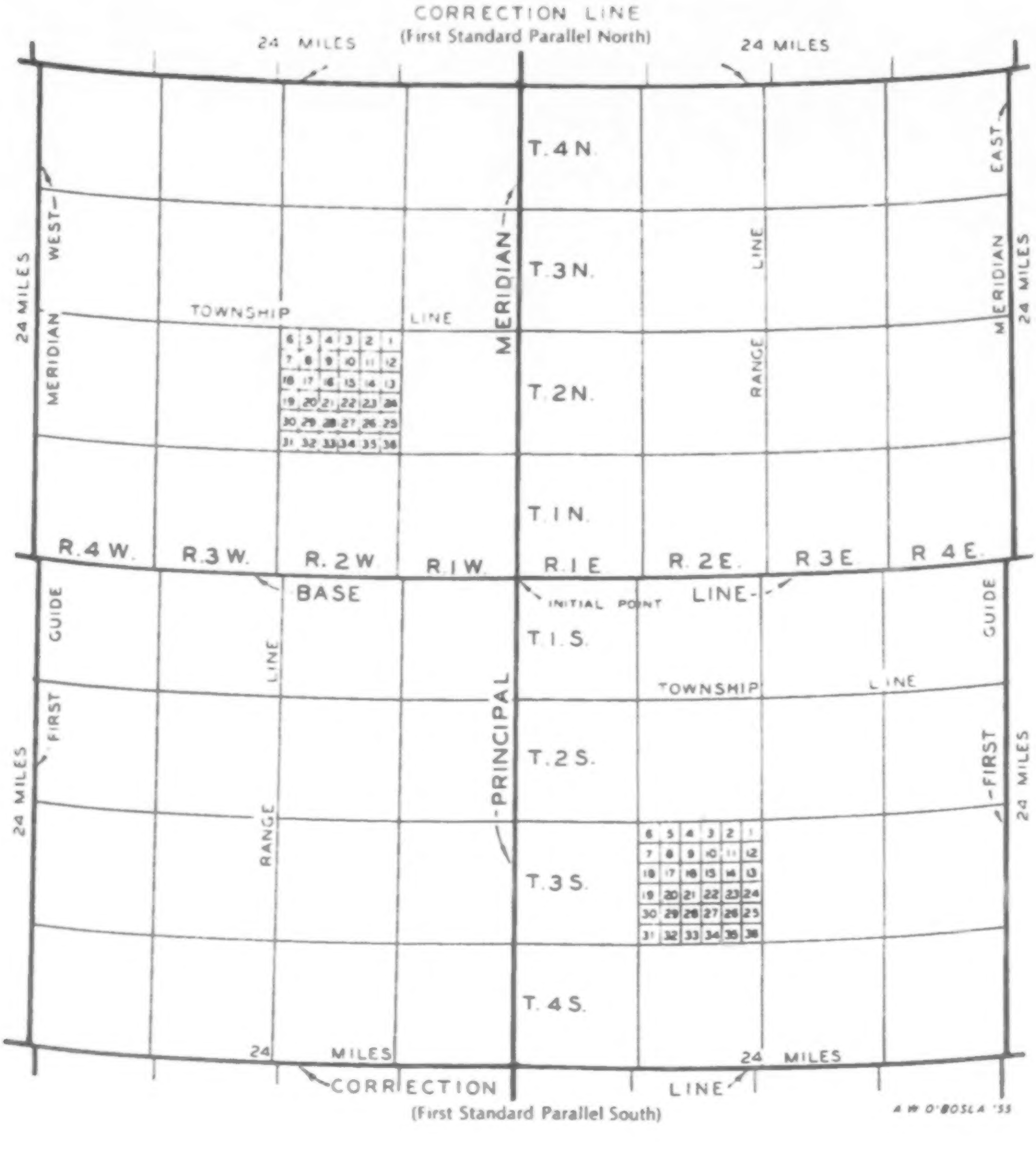
☐ 21. **Do** Additional assignments listed below.

☐ 22. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 23. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

U.S. Public Land Survey System


CORRECTION LINE
(First Standard Parallel North)
24 MILES
24 MILES
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1. S.
T. 2 S.
T. 3 S.
T. 4 S.
R. 4 W.
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
24 MILES
MERIDIAN
WEST
EAST
MERIDIAN
24 MILES
TOWNSHIP
LINE
MERIDIAN
LINE
RANGE
PRINCIPAL
BASE
INITIAL POINT
LINE
GUIDE
FIRST
24 MILES
LINE
RANGE
TOWNSHIP
LINE
GUIDE
FIRST
24 MILES
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36
24 MILES
24 MILES
CORRECTION LINE
(First Standard Parallel South)
A. W. O'BOSLA '55

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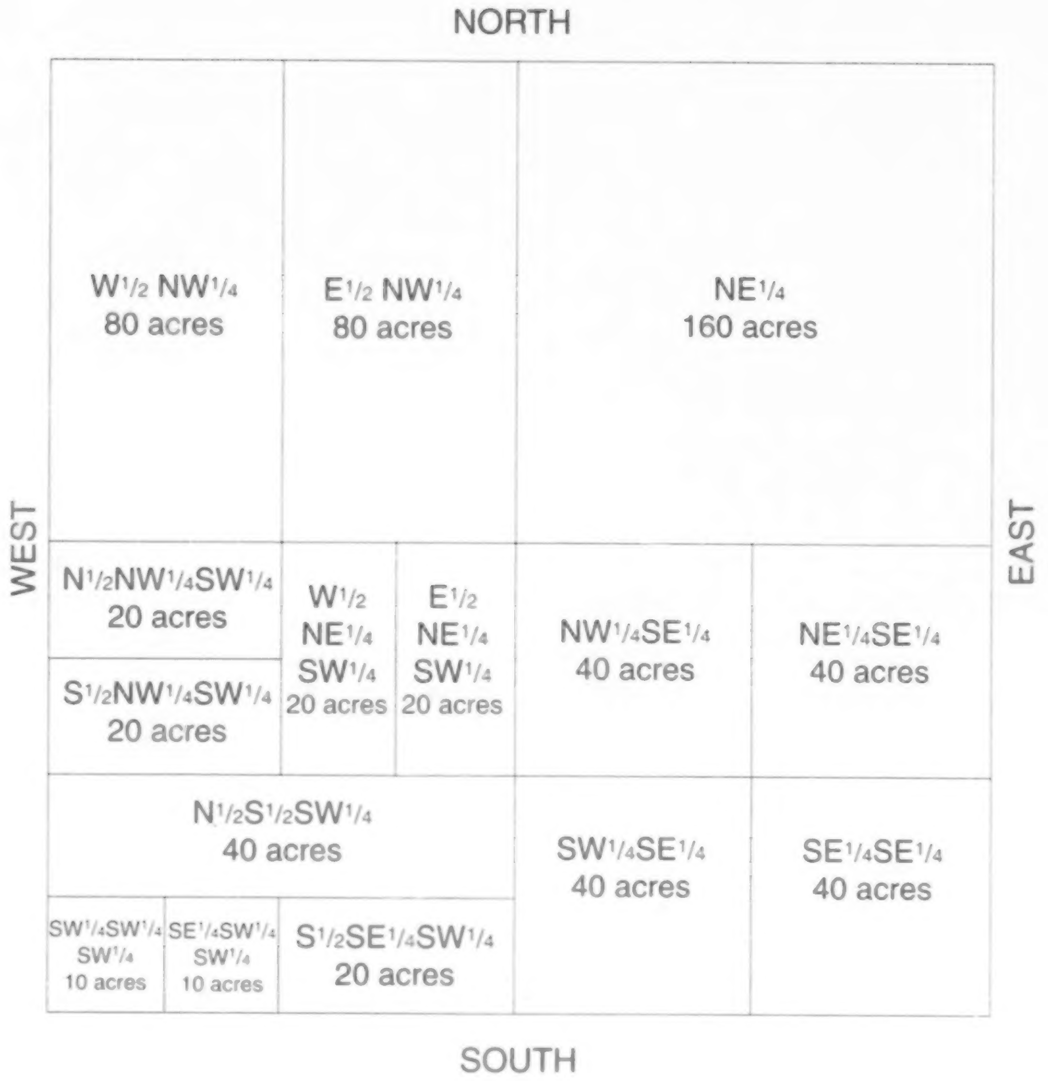
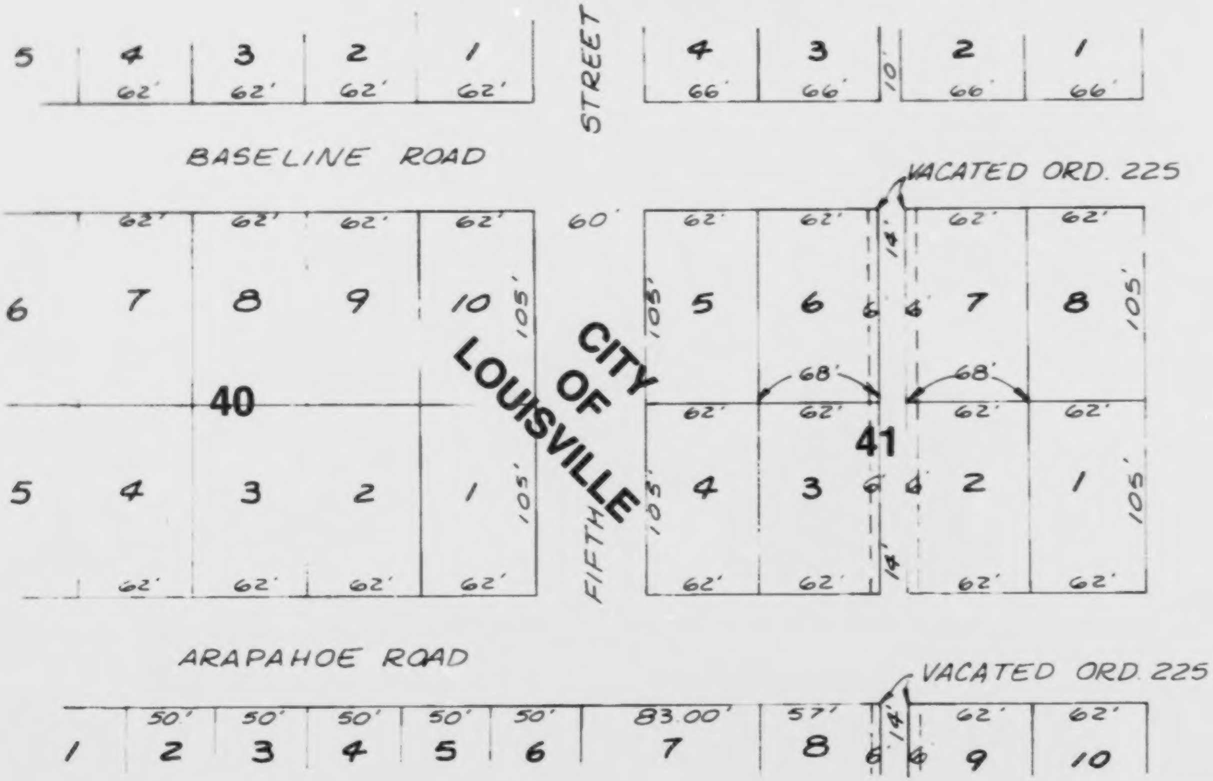
Sample Subdivision of a Section


NORTH
W½ NW¼
80 acres
E½ NW¼
80 acres
NE¼
160 acres
WEST
EAST
N½NW¼SW¼
20 acres
S½NW¼SW¼
20 acres
W½
NE¼
SW¼
20 acres
E½
NE¼
SW¼
20 acres
NW¼SE¼
40 acres
NE¼SE¼
40 acres
N½S½SW¼
40 acres
SW¼SE¼
40 acres
SE¼SE¼
40 acres
SW¼SW¼
SW¼
10 acres
SE¼SW¼
SW¼
10 acres
S½SE¼SW¼
20 acres
SOUTH

Lot and Block Description

LOT 8, BLOCK 40, BOULDER SUBDIVISION, CITY OF LOUISVILLE, BOULDER COUNTY STATE OF COLORADO


STREET
BASELINE ROAD
VACATED ORD. 225
60'
40
41
CITY OF LOUISVILLE
FIFTH
ARAPAHOE ROAD
VACATED ORD. 225
62'
66'
68'
105'
14'
10'
50'
83.00'
57'
1
2
3
4
5
6
7
8
9
10

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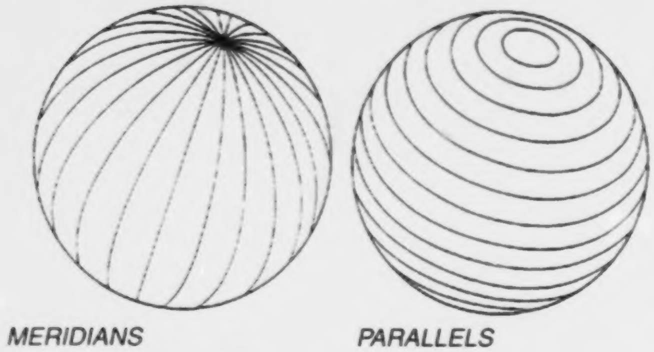
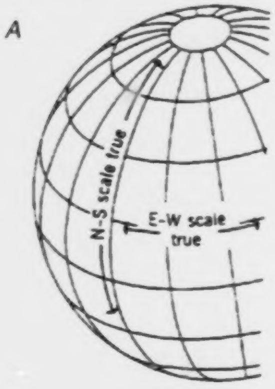
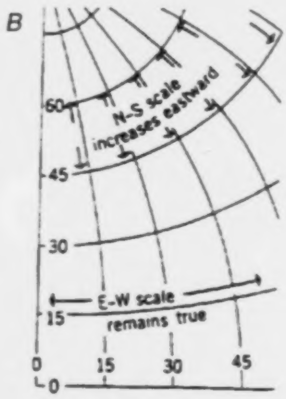
Meridians and Parallels

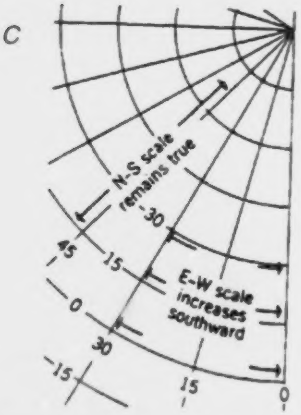

MERIDIANS
PARALLELS


A
N-S scale true
E-W scale true

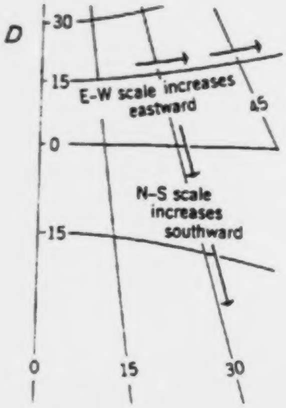
Projection for a flat map is selected according to property most desired.


B
60
45
30
15
0
N-S scale increases eastward
E-W scale remains true
0
15
30
45

Scale is true along all parallels but not along all meridians.


C
N-S scale remains true
30
45
15
0
-15
30
15
0
E-W scale increases southward

Scale true along all meridians but not along all parallels.


D
30
15
0
15
E-W scale increases eastward
45
N-S scale increases southward
0
15
30

Scale changes along both parallels and meridians.

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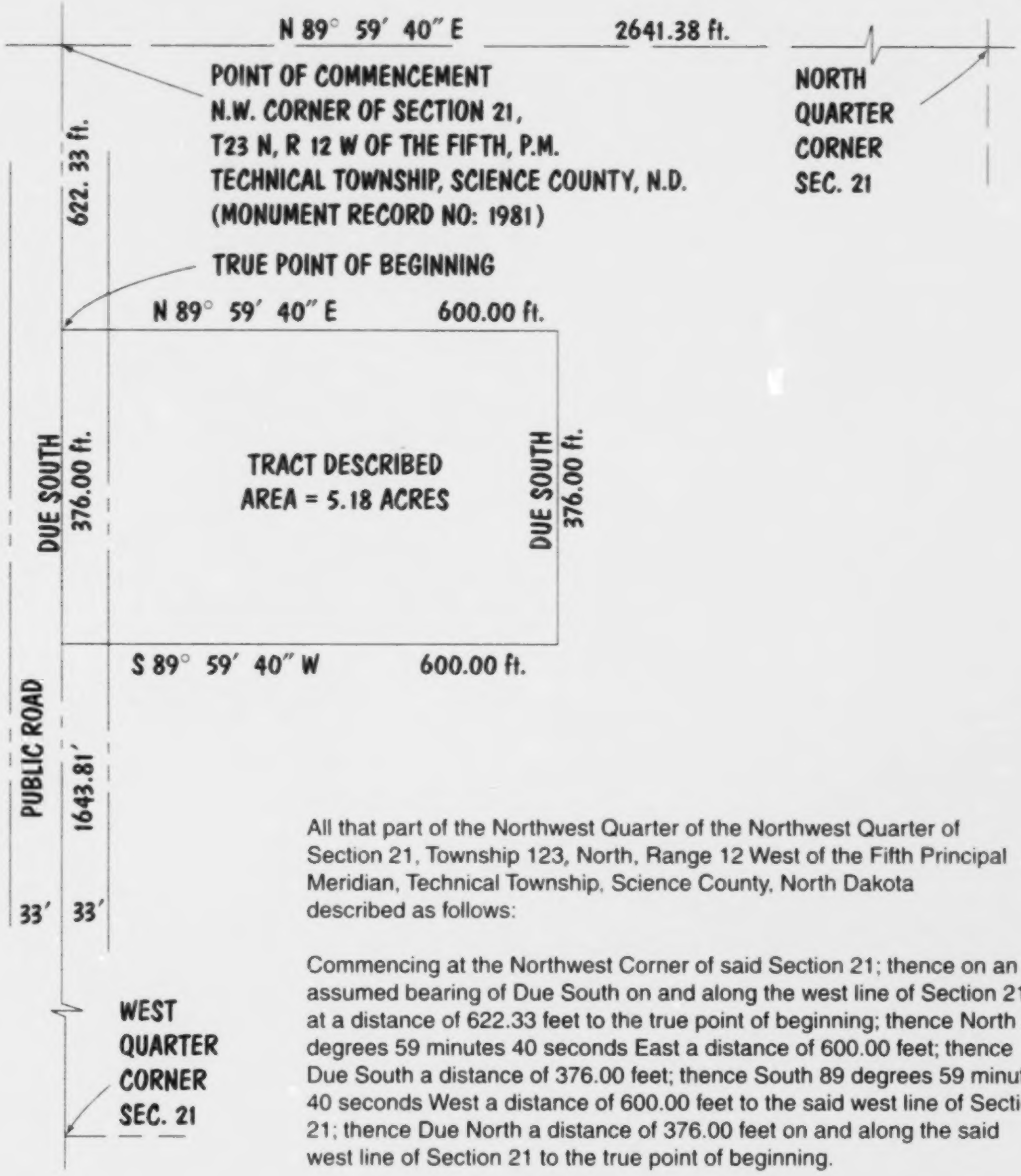
Typical Metes and Bounds Description


N 89° 59′ 40″ E
2641.38 ft.
POINT OF COMMENCEMENT
N.W. CORNER OF SECTION 21,
T23 N, R 12 W OF THE FIFTH, P.M.
TECHNICAL TOWNSHIP, SCIENCE COUNTY, N.D.
(MONUMENT RECORD NO: 1981)
NORTH QUARTER CORNER SEC. 21
622. 33 ft.
TRUE POINT OF BEGINNING
N 89° 59′ 40″ E
600.00 ft.
DUE SOUTH
376.00 ft.
TRACT DESCRIBED
AREA = 5.18 ACRES
DUE SOUTH
376.00 ft.
S 89° 59′ 40″ W
600.00 ft.
PUBLIC ROAD
1643.81′
33′
33′
WEST QUARTER CORNER SEC. 21

All that part of the Northwest Quarter of the Northwest Quarter of Section 21, Township 123, North, Range 12 West of the Fifth Principal Meridian, Technical Township, Science County, North Dakota described as follows:

Commencing at the Northwest Corner of said Section 21; thence on an assumed bearing of Due South on and along the west line of Section 21 at a distance of 622.33 feet to the true point of beginning; thence North 89 degrees 59 minutes 40 seconds East a distance of 600.00 feet; thence Due South a distance of 376.00 feet; thence South 89 degrees 59 minutes 40 seconds West a distance of 600.00 feet to the said west line of Section 21; thence Due North a distance of 376.00 feet on and along the said west line of Section 21 to the true point of beginning.

The above described tract contains 5.18 acres more or less and is subject to an existing public road over and across its most westerly 33.00 feet.

Reference System Spacing for State Plane Coordinates

	State Plane Coordinate			UTM		
Map scale	Tick spacing (ft on ground)	Spacing (on map) inches	mm	Grid spacing (m on ground)	Spacing (on map) inches	mm
1:20,000	10,000	6.0	152.4	1,000	1.97	50.0
1:24,000	10,000	5.0	127.0	1,000	1.64	41.6
1:25,000	10,000	4.8	122.0	1,000	1.57	40.0
1:50,000	20,000	4.8	122.0	5,000	3.94	100.0
1:62,500	20,000	3.84	97.5	5,000	3.15	80.0
1:63,360	20,000	3.78	96.0	5,000	3.10	78.7
1:100,000	50,000	6.0	152.4	10,000	3.94	100.0
1:250,000	100,000	4.8	122.0	10,000	1.57	40.0
1:500,000	200,000	4.8	122.0	50,000	3.94	100.0
1:1,000,000	500,000	6.0	152.4	100,000	3.94	100.0

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Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Invite a speaker to class to discuss the legal importance of field notes.
- Arrange a field trip with a local surveyor to observe a surveying team in the field.
- Visit an engineering supply firm to look at surveying equipment, including GPS and data collectors.
- Show examples of different types of drawings made in civil drafting as they correspond to the different types of surveys.
- Have students conduct a small field survey to locate points of elevations and distances.
- Provide students with a copy of the MAVCC Topographic Survey Lot Diagram included in the Appendix for use in completing Assignment Sheet 7.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- Brinker, Russell C. and Paul R. Wolf. *Elementary Surveying*, 9th ed. New Jersey: Prentice-Hall, Inc., 1998.
- Brown, Walter and Clois E. Kicklighter. *Drafting for Industry*. South Holland, IL: Goodheart-Willcox Co., Inc., 1995.
- *Definitions of Surveying and Associated Terms*. American Congress on Surveying and Mapping and the American Society of Civil Engineers. (Out of print)

- *Glossaries of BLM Surveying and Mapping Terms*, 2nd ed. Bureau of Land Management/U.S. Department of the Interior.
- *Journal of Surveying Engineering*. Quarterly journal of the American Society of Civil Engineering.
- Madsen, David and Terence Shumaker. *Civil Drafting Technology*, 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc. 1997.
- *Map Drafting and Related Computations for Plane Surveying: Field Book*. Natchitoches, LA: Vocational Curriculum Development and Research Center.
- McCormac, Jack C. *Surveying Fundamentals*. Englewood Cliffs, NJ: Prentice-Hall, 1995. ISBNO-13-031162-6.
- *Photogrammetric Engineering and Remote Sensing*. Monthly journal of the American Society for Photogrammetry and Remote Sensing.
- *Satellite Solution to Surveying*. Vol. 2, No. 6, pp. 13-17. J. Collins. Nov/Dec 1982.
- *Surveying and Land Information Systems*. Quarterly journal of the American Congress on Surveying and Mapping.
- www.anderson@.andassoc.com. University of Texas.

Suggested Supplemental Resources

Professional Surveying Organizations

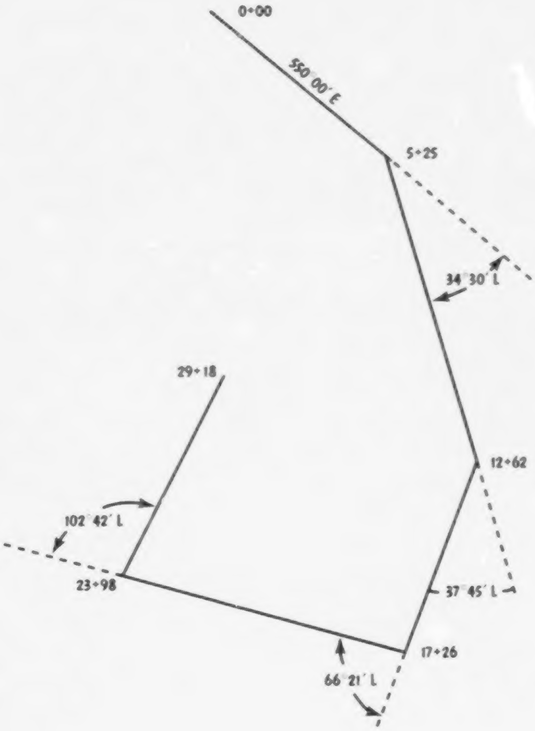
- American Congress on Surveying and Mapping (ACSM)
- American Society for Photogrammetry and Remote Sensing (ASPRS)
- Surveying Engineering Division of the American Society of Civil Engineers (ASCE)
- Urban and Regional Information Systems Association (URISA)
- Automated Mapping and Facilities Management (AM/FM)
- Canadian Institute of Geomatics (CIG)
- Canadian Institute of Surveying and Mapping (CISM)
- International Federation of Surveyors (IFS)

Answers to Assignment Sheets

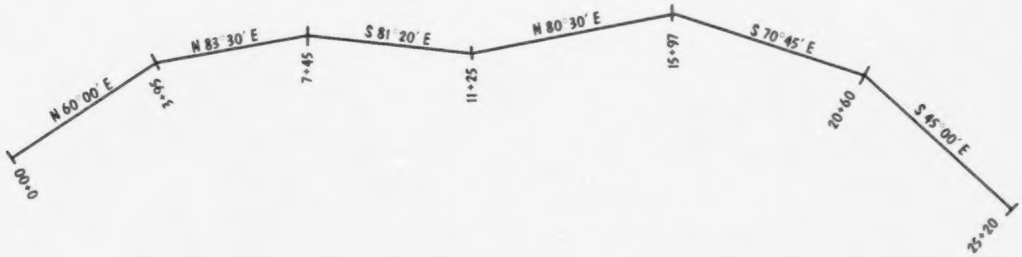
Assignment Sheet 1

Plot Lines and Distances Using Several Methods

Problem 1: Deflection angles


0+00
S50°00′E
5+25
34°30′ L
29+18
12+62
102°42′ L
23+98
37°45′ L
17+26
66°21′ L

Problem 2: Bearings


N 60°00′ E
N 83°30′ E
S 81°20′ E
N 80°30′ E
S 70°45′ E
S 45°00′ E
0+00
3+95
7+45
11+25
15+97
20+60
25+20

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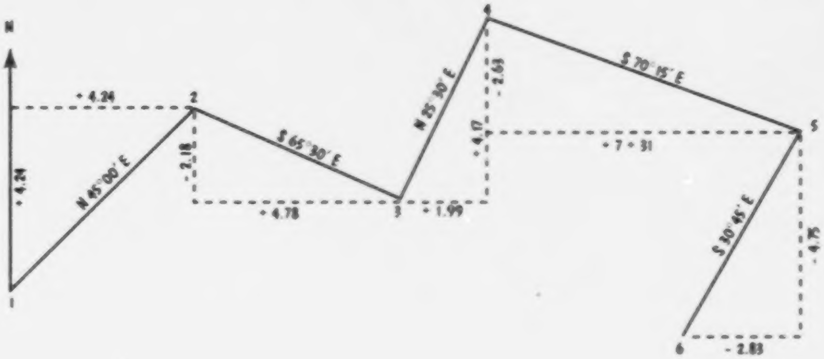
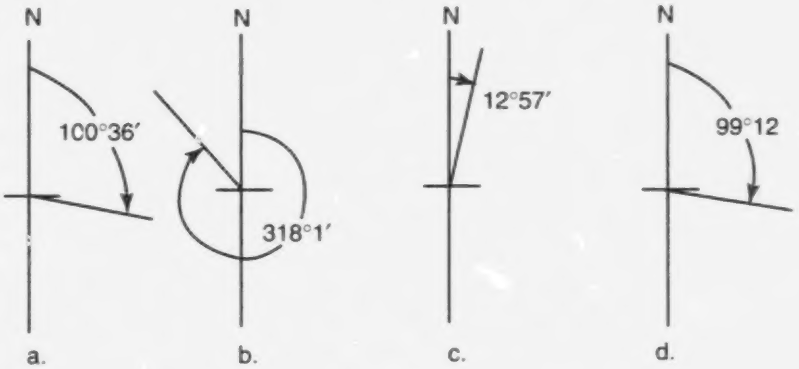
Problem 3: Latitudes and departures


N
1
2
3
4
5
6
+ 4.24
+ 4.24
N 45°00' E
- 2.18
S 65°30' E
+ 4.78
+ 1.99
N 25°30' E
+ 4.17
- 2.63
S 70°15' E
+ 7.31
S 30°45' E
- 4.75
- 2.83

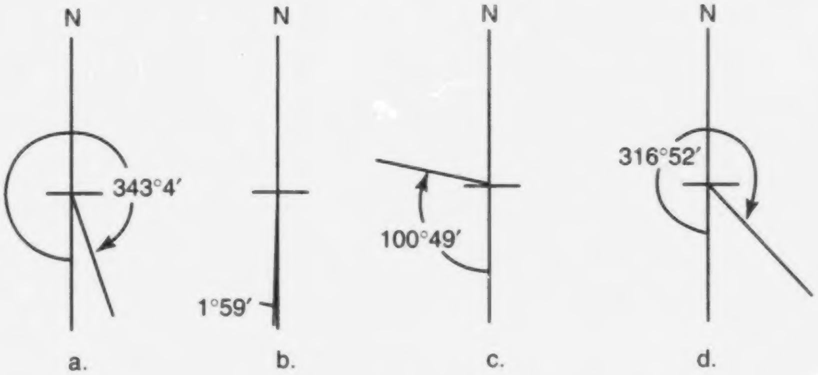
Assignment Sheet 2

Convert Azimuths to Bearings and Bearings to Azimuths

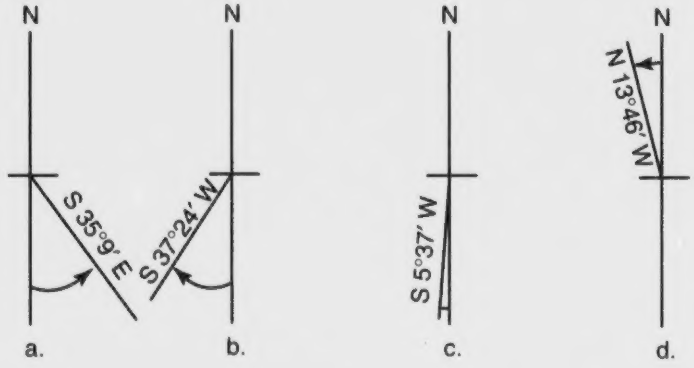
Problem 1: Bearings to azimuths (N)


N
100°36'
a.
N
318°1'
b.
N
12°57'
c.
N
99°12
d.

Problem 2: Bearings to azimuths (S)

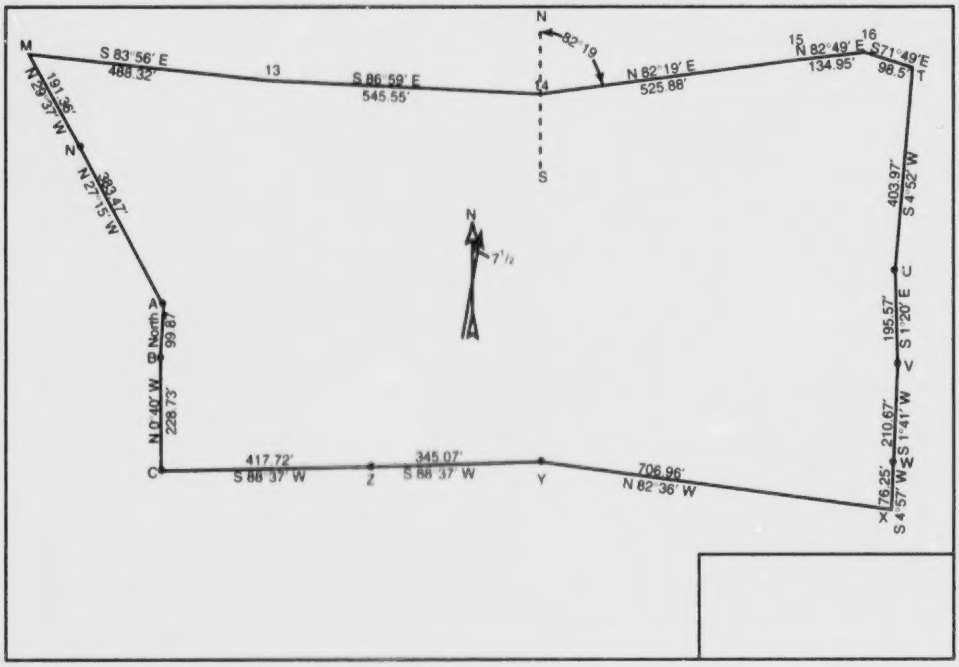

N
343°4'
a.
N
1°59'
b.
N
100°49'
c.
N
316°52'
d.

Problem 3: Azimuth to bearing


N
S 35°9′ E
a.
N
S 37°24′ W
b.
N
S 5°37′ W
c.
N
N 13°46′ W
d.

Assignment Sheet 3

Lay Out a Closed Traverse


M
S 83°56′ E
488.32′
13
S 86°59′ E
545.55′
N
82°19
14
S
N 82°19′ E
525.88′
15
N 82°49′ E
134.95′
16
S71°49′E
98.5′
T
191.36′
N 29°37′ W
N
383.47′
N 27°15′ W
A
North
99.87
B
N 0°40′ W
228.73′
C
417.72′
S 88°37′ W
Z
345.07′
S 88°37′ W
Y
706.96′
N 82°36′ W
X
N
7½
403.97′
S 4°52′ W
U
195.57′
S 1°20′ E
V
210.67′
S 1°41′ W
W
76.25′
S 4°57′ W

Answers to Assignment Sheets

Assignment Sheet 4 Complete a Mathematical Closure of a Traverse

COURSE	DIST.	Bearing	SIN	COS	LATITUDE		DEPARTURE	
					N (+)	S (—)	E (+)	W (—)
A-B	529.60	N48°20′E			352.08		395.63	
B-C	592.0	N87°43′E			23.58		591.53	
C-D	563.6	S7°59′E				558.14	78.28	
D-E	753.4	S82°12′W				102.25		746.43
E-A	428.2	N48°12′W			285.41			319.21
					661.07	660.39	1065.44	1065.64
					—660.39			—1065.44
				Diff. =	.68			.20

$TE = \sqrt{(.68)^2 + (.20)^2}$

$TE = \sqrt{(.46240) + (.04)}$

$TE = \sqrt{.50240} = .7088 = .71$

Relative Error = $\frac{.71}{2866.8} \quad \frac{1}{4037.75}$

Error is 1′ in 4037.75′

Reduce Four Types of Field Notes

Problem 1: Differential level

⑭ DIFFERENTIAL LEVEL NOTES

10-21-85
8:05 A.M.
CLOUDY, WINDY +38°

CEC
RLS

STA	BS	HI	FS	ROD	ELEV.	
BM_1					1000.00	ARBITRARY ELEV. SET ON TOP NUT OF F.H. @
	2.55	1002.55				CORNER OF 3RD AVE. NORTH & 12th ST. WEST
TP_1			2.78		999.77	SHOT ON CURB
	2.98	1002.75				
TP_2			3.28		999.47	STREET LIGHT BASE
	3.92	1003.39				
TP_3			4.79		998.60	ON CURB
	5.04	1003.64				
TBM_1			5.11		998.53	"X" ON N.W. COR. OF FRONT STEP-ENTRANCE
	5.18	1003.71				TO SCHERTZ MANUFACTURING
TP_4			5.09		998.62	F.H.
	5.03	1003.65				
TP_5			4.77		998.88	CURB
	4.12	1003.00				
TP_6			3.50		999.50	CURB
	2.95	1002.45				
BM_1			2.45		1000.00	SAME AS ABOVE - CHECKED BACK IN.
	31.77		31.77		CK OK	
		CK OK				
				SAME AS STARTING ELEV.		

Problem 2: Miscellaneous level shots @ random

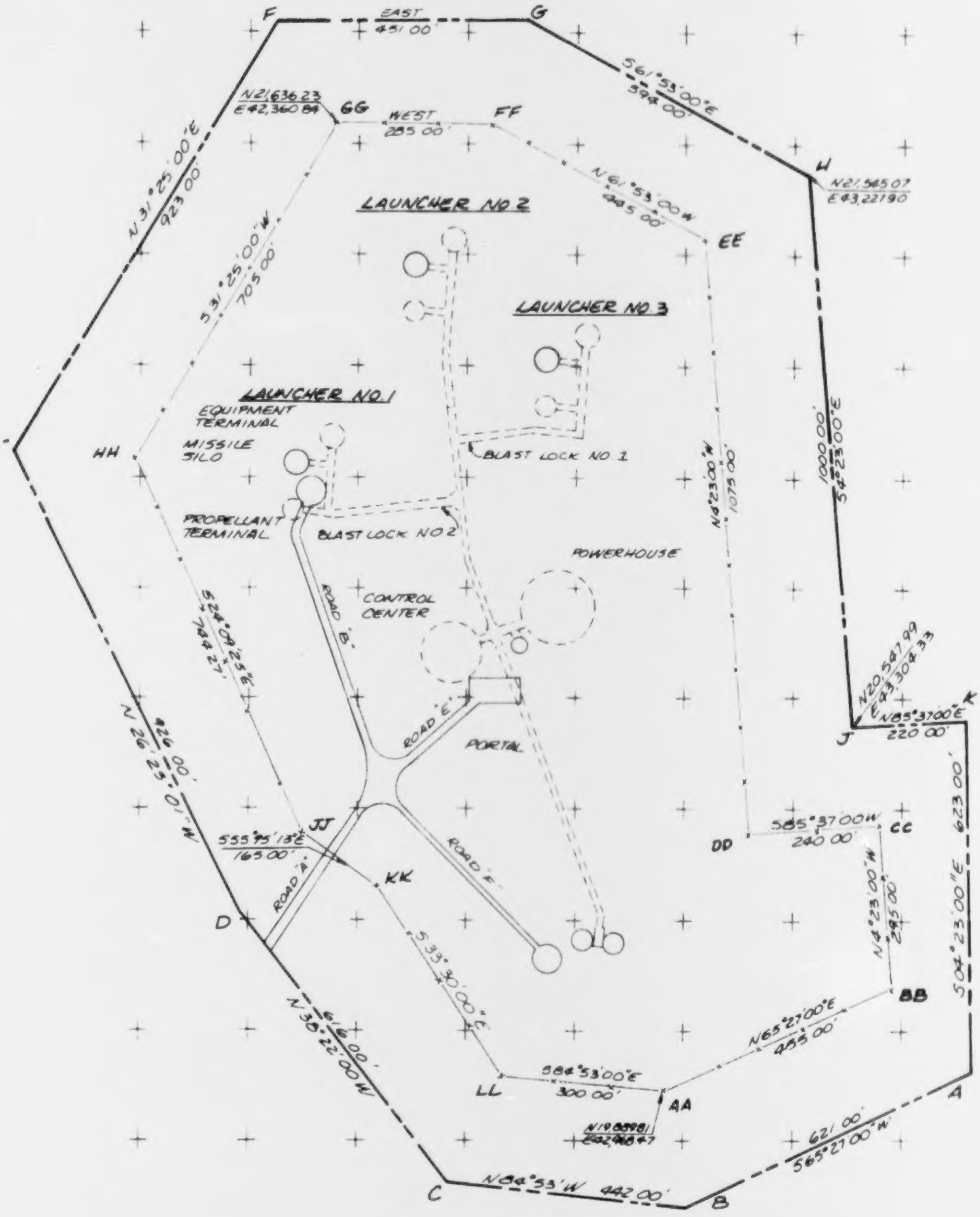
⑫		MISC LEVEL SHOTS @ RANDOM				9-10-85 2:30 P.M.		T.S. F.G.
						CLEAR, 75°, CALM		
STA	BS	HI	FS	ROD	ELEV.			
BM₁					6324.49		N.W. CORNER OF LIGHT POLE ON THE	
	5.02	6329.51					CORNER OF 7th ST. AND 4th AVE SW	
				2.31	6327.20		TOP NUT OF FIRE HYDRANT	
				1.36	6328.15		N TAN. SW CORNER OF 7th ST & 4th AVE.	
				2.55	6326.96		SE CORNER OF SLAB OF MAILBOX (702)	
TP₁			1.06		6328.45	(ROCK)		
	4.28	6332.73						
				3.44	6329.29		N INT OF DRWY AND CURB (716)	
				1.26	6331.47		NW CORNER OF FIRST STEP (711)	
TP₂			4.32		6328.41	(CURB)		
	.79	6329.20					NUMBERS IN PARENTHESIS ARE	
BM₁			4.71		6324.49	(SAME AS ABOVE)	HOUSE NUMBERS	
					CK OK.			
	10.09	⟷	10.09					
		CK OK		SAME AS STARTING ELEV.				

⑱	PROFILE LEVEL NOTES - 10th AVE. NW					8-25-85 9:00 A.M SUNNY, WINDY, +42°	CEC RLS
STA.	BS	HI	FS	ROD	ELEV.		
BM1					1790.40	STREET LIGHT BASE @ COR. OF 10th AVE. N &	
	5.22	1795.62				2ND ST. W	
0+00				3.46	1792.16		
0+50				4.14	1791.48		
1+00				4.82	1790.80		
1+50				5.29	1790.33		
TP1			5.37		1790.25	SHOT ON CURB	
	4.10	1794.35					
2+00				4.88	1789.47		
2+50				5.21	1789.14		
3+00				5.96	1788.39		
3+50				6.33	1788.02		
TP2			6.05		1788.30	SHOT ON DRIVEWAY	
	5.30	1793.60					
4+00				4.94	1788.66		
4+50				5.62	1787.98		
TP3			5.10		1788.50	SHOT ON CURB	
	6.55	1795.05					
BM1			4.65		1790.40	SAME AS ABOVE (CHECKED IN)	
	21.17		21.17		CK OK		
		CK OK					
			SAME AS STARTING ELEV.				

Problem 4: Cross section

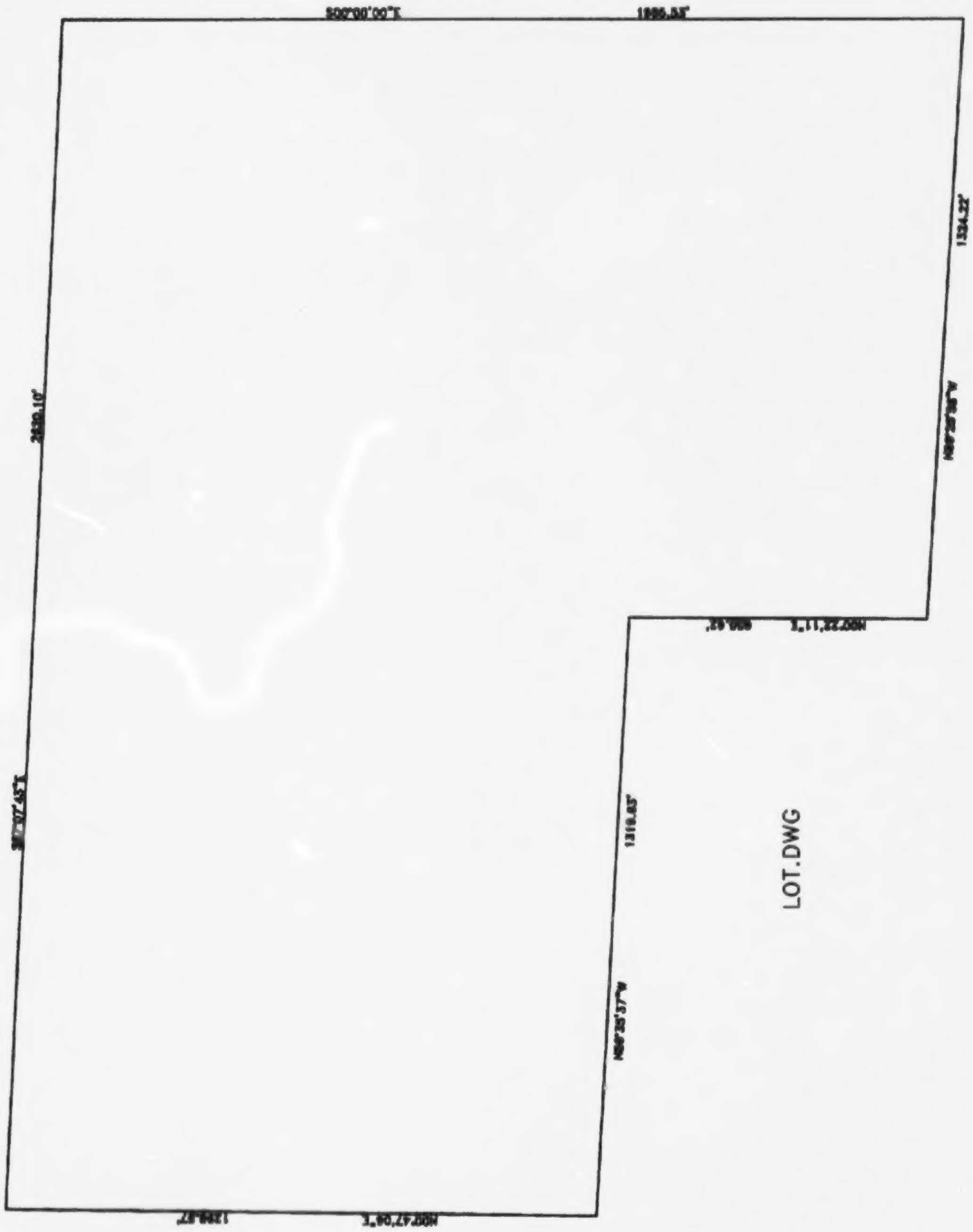
⑯	CROSS SECTION NOTES (CO. RD 19)					10/23/85 11:00am	SUNNY, CALM, +65				CEC RLS
STA.	BS	HI	FS		ELEV	SHOTS N			SHOTS S		
								℄			
BM$_1$					1742.20						
	4.26	1746.82				BM$_1$ IS NAIL IN P.P. @ INT. OF ROAD (PAINTED RED)					
0+00						1746.82 42.0 4.8 50'	41.9 4.9 25'	41.6 5.2 0	41.7 5.1 25'	41.5 5.3 50'	
0+30						40.9 40.5 5.9 6.3 50' 24'	40.9 41.4 5.9 5.4 18' 12'	42.6 4.2 0	42.5 41.2 4.3 5.6 10' 16'	40.6 6.2 23'	41.6 5.2 50'
0+50						40.8 40.6 6.0 6.2 50' 25'	40.7 41.2 6.1 5.6 19' 13'	42.3 4.5 0	42.2 41.1 4.6 5.7 11' 17	40.5 6.3 24'	41.4 5.4 50'
1+00						41.0 40.2 5.8 6.6 50' 24'	40.5 41.1 6.3 5.7 19' 12'	42.4 4.4 0	42.3 41.0 4.5 5.8 10' 17'	40.1 6.7 22'	41.0 5.8 50'
TP$_1$			5.14		1741.68	NAIL IN POWER POLE					
	4.16	1745.84									
1+50						1745.84 40.54 5.3 50'	39.94 39.14 5.9 6.7 26' 18'	40.24 41.24 5.6 4.6 10' 0	41.14 40.14 4.7 5.7 11' 19'	39.34 6.5 26'	40.54 5.3 50'
2+00						39.84 6.0 50'	39.14 39.04 6.7 6.8 27' 20'	39.94 40.94 5.9 4.9 12' 0	40.84 39.84 5.0 6.0 12' 20'	39.14 6.7 28'	40.44 5.4 50'
TP$_2$			4.18		1741.66	ROCK					
	5.24	1746.90									
			4.70		1742.20	SAME AS ABOVE					
	14.02		14.02								
		CK OK									

Assignment Sheet 6 **Draw a Map Using Bearings, Distances, and Coordinates**


F
EAST
451.00'
G
S61°53'00"E
594.00'
H
N21,585.07
E43,227.90
N21,636.23
E42,360.84
GG
WEST
285.00'
FF
N61°53'00"W
495.00'
EE
N31°25'00"E
923.00'
S31°25'00"W
705.00'
LAUNCHER NO 2
LAUNCHER NO 3
LAUNCHER NO.1
EQUIPMENT TERMINAL
MISSILE SILO
HH
BLAST LOCK NO 1
PROPELLANT TERMINAL
BLAST LOCK NO 2
N4°23'00"W
1075.00'
1000.00'
S4°23'00"E
POWERHOUSE
ROAD 'B'
CONTROL CENTER
S24°09'25"E
784.27'
N20,547.99
E43,304.33
K
N85°37'00"E
220.00'
J
ROAD 'E'
PORTAL
N26°25'0"W
926.00'
623.00'
S04°23'00"E
JJ
S55°45'13"E
165.00'
KK
ROAD 'F'
DD
S85°37'00"W
240.00'
CC
N4°23'00"W
295.00'
D
ROAD 'A'
S33°30'00"E
BB
N65°27'00"E
455.00'
616.00'
N30°22'00"W
LL
S84°53'00"E
300.00'
AA
A
N19,889.81
E42,918.47
621.00'
S65°27'00"W
C
N84°53'W 442.00'
B

Answers to Assignment Sheets

Assignment Sheet 7 **Lay Out the Property Boundary For the MAVCC Topographic Survey Map**


S00°00'00"E
2530.10'
1334.22'
1319.83'
N00°47'06"E
LOT.DWG

Written Test

Name ____

Date ______________________________ Score ____________

Objective 1

Match terms related to interpretation of surveyor's notations with their definitions. Terms and definitions continue on the next page.

1. Azimuth
2. Back bearing
3. Backsight
4. Base line
5. Beaman arc
6. Bearing
7. Benchmark
8. Blunder
9. Circumference
10. Course

_____ a. The bearing or azimuth and length of a line

_____ b. A surveyed line, normally straight, with measured increments called stations; often used for control work on engineering projects and as a method of collecting existing ground features

_____ c. The calculated or measured distance around a circular object

_____ d. A mistake due to human error that can be discovered unless negligible

_____ e. The direction of the line expressed by the acute angle with respect to a reference meridian which can be north or south

_____ f. The horizontal direction reckoned clockwise from the meridian plane, usually measured in degrees, minutes, and seconds from 0° to 360°

_____ g. Sighting that is taken from the survey instrument back to an existing point of elevation

_____ h. A specially graduated arc attached to the vertical circle of an alidade or transit to simplify computing elevation difference for inclined stadia sights

_____ i. A relatively permanent material object, natural or artificial, bearing a marked point whose elevation above or below an adopted datum is known

_____ j. Bearing of a station to a preceding station

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Written Test

11. Datum
12. Elevation
13. Field book
14. Foresight
15. Grid
16. Horizontal angle
17. Horizontal length
18. Hub
19. Latitude and departure
20. Monument
21. Parameter
22. Point
23. Reconnaissance
24. Recorded

_____ k. The common term for the collection base of all field data; usually either a bound book or a loose-leaf binder-type book

_____ l. The straight line distance measured in a horizontal plane

_____ m. Sighting a point forward of the survey instrument

_____ n. Any numerical or geometric quantity or set of such quantities which may serve as a reference or base for other quantities

_____ o. A surveying term used to signify writing down or transcribing field data into a field book

_____ p. A common surveying abbreviation which represents an accurate position of a surveyed station

_____ q. The difference in direction between two intersecting vertical planes, or two intersecting lines of sight; usually measured in degrees, minutes, and seconds

_____ r. A set of physical properties whose values determine the characteristics of a system

_____ s. A physical structure, such as an iron post, marked stone, or tree in place, which marks the location of a corner point established by a cadastral survey

_____ t. The position of a point, line, traverse, triangulation, or grid can be defined by coordinates which are northerly or southerly (latitudes), measured from an arbitrarily chosen east-west (x) axis, and easterly and westerly (departures) measured from an arbitrarily chosen north-south (y) axis

_____ u. A substantially square stake, usually driven flush with the ground, with a tack marking the survey point

_____ v. A series of measured parallel and perpendicular reference lines laid out an equal distance apart to form equal squares

_____ w. A normal preliminary stage of a project used to evaluate approaches to surveying projects, collect preliminary data, and familiarize oneself with the site

_____ x. The vertical distance from a datum, generally means sea level, to a point or object on the earth's surface

25. Station
26. Surveying
27. Traverse
28. Traversing
29. Triangulation
30. Vertical angle
31. Vertical length

_____ y. A measurement of a difference in height or elevation

_____ z. A surveying procedure used to determine the direction and length of a series of lines known as courses

_____ aa. Arbitrary points established in a survey usually located 100 feet apart

_____ bb. The difference in direction between a horizontal plane and an intersecting line, plane, or a line of sight to a point

_____ cc. A number of points (called traverse stations) connected in series between horizontal angles by horizontal lengths; may be open or closed

_____ dd. The science of determining the dimensions and contours of the earth's surface by measurements of distances, directions, and elevations; computations of areas and volumes; and the preparation of necessary maps

_____ ee. A series of connecting triangles in which a side of one and the angle of all are measured and the remaining sides are computed by trigonometry

Objective 2

List six activities that define surveying according to the International Federation of Surveyors.

a. ____

____

____

b. ____

____

____

c. ____

____

____

d. ____

____

____

e. ____

____

____

f. ____

____

____

Objective 3

Select true statements concerning the classifications of surveys by placing an "X" in the blanks next to the true statements.

_____ a. Geodetic survey measurements are located by global positioning system (GPS).

_____ b. A plane survey considers the Earth to be a round surface.

_____ c. A geodetic survey is usually performed by private companies.

_____ d. A plane survey is a survey with a lower order of accuracy.

Objective 4

Match the types of surveys with their descriptions. Descriptions continue on the next page.

1. Control survey
2. Topographic survey
3. Land boundary surveys
4. Cadastral survey
5. Hydrographic survey
6. Route survey
7. Construction survey
8. As-built survey
9. Geological and forestry survey
10. Mine survey
11. Marine survey
12. Photogrammetric survey
13. Satellite survey

_____ a. Similar to hydrographic survey but covers larger area

_____ b. Determination of ground location from measurements made to satellites using GPS receivers; used to survey large areas

_____ c. Establishes a network of horizontal and vertical monuments that serve as a reference framework for other surveys

_____ d. Defines shorelines and depths of lakes, streams, oceans, and reservoirs

_____ e. Determines artificial and natural land features locations and elevations used in map making for topographic maps

_____ f. Used in the preparation of geological maps and forest management

_____ g. Involves the plan, design, and construction of highways, railroads, pipelines, and other lineal projects which align with the state plane coordinate system

_____ h. Used to determine relative elevation and position of underground shafts, geological formations, earthwork quantities, and to establish lines and grades

_____ i. Done by use of aerial photographs in conjunction with limited ground survey that involves panel points; ideal for lands with limited access

_____ j. Closed surveys to establish property lines and corners

_____ k. Provides for location of structures, required elevation points for construction and earthwork quantities but not limited to buildings

_____ l. Generally used for surveys of the public lands system

_____ m. Made after the construction project is complete to provide the position and dimensions of features of the project as constructed

Objective 5 Define types of computer-based digital data files.

a. Land Information Systems ______________________________

b. Geographic Information Systems ______________________________

Objective 6 List six U.S. government agencies that perform surveying.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Objective 7 List three types of measurements used in surveying.

a. ______________________________

b. ______________________________

c. ______________________________

Written Test

Objective 8

Select true statements about important characteristics in surveying measurement by placing an "X" in the blanks next to the true statements.

_____ a. Units of measurement include length, area, volume, and angle.

_____ b. Rules for rounding off numbers don't apply in survey measurement.

_____ c. Accuracy in a recorded measurement is attained by the number of digits (significant figures) recorded.

_____ d. Accuracy of measurement depends on scale division, reliability of equipment, and human limitations.

Objective 9

Define accuracy and precision.

a. Accuracy ____

____

b. Precision ____

____

Objective 10

Select true statements concerning accuracy ratio by placing an "X" in the blanks next to the true statements.

_____ a. Accuracy ratio determines the order of accuracy of work to be performed.

_____ b. Error of closure is the difference between the measured location and the theoretically correct location of the same point.

_____ c. Accuracy of a measure is the ratio of error in the measurement to the distance measured.

Objective 11

Match types of errors with their examples.

1. Systematic errors
2. Mistakes or blunders
3. Random errors

_____ a. Transposing figures, miscounting full tape lengths, measuring to or from the wrong point, and arithmetic mistakes

_____ b. Slope in measurement, erroneous tape length, temperature variations, and improper tension

_____ c. Improper plumbing, faulty marking, incorrect reading or interpolation, and misalignment

Objective 12

Match types of surveying equipment with their uses.

1. Transit
2. Chain/tape
3. Electronic distance meter
4. Total station
5. Theodolite
6. Levels
7. Level rod
8. Data collector
9. Field books
10. Planetable and alidade

_____ a. Emits a signal of electromagnetic energy from a position to a receiver at another position; the signal is returned from the receiver to the instrument such that two times the distance between the two positions can be measured

_____ b. Used primarily for measuring horizontal and vertical angles, prolonging and setting points in line, measuring approximate distances by the stadia principles, and for leveling operations

_____ c. Accomplishes the same tasks as a transit through optical means that are more accurate

_____ d. Used to measure horizontal distances; several types are used

_____ e. Measures distance and direction simultaneously and transmits the results automatically to a built-in computer

_____ f. Used to collect point locations from the field

_____ g. Used to establish the elevation of different points on the ground; several types used

_____ h. Used for recording survey notes and layout and construction data

_____ i. Used for obtaining detail and topography

_____ j. A straight rod or bar with a flat face graduated in linear units with zero at the bottom, used in measuring the vertical distance between a point on the ground and the horizontal line of sight of a leveling instrument

Objective 13

Select true statements concerning methods used in surveying to measure horizontal distances by placing an "X" in the blanks next to the true statements.

_____ a. A pedometer is used to measure feet.

_____ b. The odometer is the most accurate method to measure horizontal distances.

_____ c. Stadia measurement can be taken with a transit.

_____ d. Chains are an older method of measurement.

_____ e. Distance measurement is done by measuring the time a wave travels to an established point.

Written Test

Objective 14

List four methods used to determine horizontal point positions.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Objective 15

Define triangulation.

____

____

____

Objective 16

Complete the following statements concerning traverses by filling in the blanks with the correct answers.

a. The points where the courses ____________ are known as traverse stations.

b. Horizontal directions are given in terms of ____________ or ____________.

c. Traverses consist of a series of lines known as ____________.

Objective 17

Distinguish between bearing direction and azimuth direction by placing a "B" for bearing in the blanks next to bearing descriptions.

_____ a. Is measured from the north or south end of a meridian towards east or west

_____ b. Range of angle is 0° to 90°

_____ c. Range of angle is 0° to 360°

_____ d. The reference is usually north

_____ e. Is measured clockwise only

Objective 18

State the formulas to convert bearings to azimuths and azimuths to bearings.

a. Bearing to azimuth

b. Azimuth to bearing

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Objective 19

Select true statements concerning common methods for plotting traverses by placing an "X" in the blanks next to the true statements.

_____ a. Three sets of data must be known to plot interior angles.

_____ b. Distance and bearing method is the easiest.

_____ c. Azimuth traverses present a series of lines that are related to one another by angle measurement only.

_____ d. An advantage to using deflection angles is they are used to calculate curves of parking lots.

_____ e. Angle to the right courses running east only are (—) departures.

_____ f. Rectangular coordinates are the most commonly used method of referencing points obtained from a field crew or giving data to a crew.

Objective 20

Complete the following statements about vertical angles by filling in the blanks with the correct answers.

a. A vertical angle is the difference in direction between two _______________ lines measured in a vertical plane.

b. Transits measure _______________ angles.

c. A nadir angle is measured from a point directly _____________ the observer.

Objective 21

Define leveling.

____

____

Objective 22

Match the terms for basic leveling with their definitions.

1. Plumb bob
2. Vertical line
3. Level surface
4. Elevation
5. Level line
6. Horizontal line

_____ a. The surface of a constant elevation that is perpendicular to the plumb line at every point

_____ b. A straight line tangent to a level line at one point

_____ c. The vertical distance above or below a reference level surface (normally sea level) of a particular point

_____ d. A pear-shaped weight with a pointed bottom which is suspended on a string or wire to establish a vertical line

_____ e. A curved line in which all points are of equal elevation along a level surface

_____ f. A line parallel to the direction of gravity, the direction assumed by the plumb bob when allowed to swing freely

Written Test

Objective 23

Complete the following statements concerning reference elevations by filling in the blanks with the correct answers.

a. A ____________________, called a benchmark, is a point whose elevations have been precisely determined and is usually made of concrete and has a brass disk embedded in it.

b. In the United States, the ____________________ datum is used by surveyors.

Objective 24

List four pieces of equipment that can be used to level.

a. ____

b. ____

c. ____

d. ____

Objective 25

Select true statements concerning developing a profile from profile leveling notes by placing an "X" in the blanks next to the true statements.

_____ a. States are set up at irregular intervals.

_____ b. Station 0+00 is the beginning point.

_____ c. A TP is a tool to dig a hole for a monument.

_____ d. The foresight readings are subtracted from the HI to obtain the elevations.

Objective 26

Select true statements concerning stationing by placing an "X" in the blanks next to the true statements.

_____ a. The distance between full stations is 50 feet.

_____ b. Survey distances are recorded by stations.

_____ c. A fractional part of a station is called a half station.

_____ d. Beginning point of an open traverse is labeled station 0+00.

Objective 27

Complete the following statements concerning field notes by circling the word(s) that best complete each statement.

a. Are (**temporary, permanent**) records of work done in the field

b. The Reinhardt system of (**upper and lower case, all upper case**) lettering is used as the lettering style to record notes.

c. Notes are lettered with a sharp (**soft, hard**) pencil.

d. Erasing observed data (**is, is not**) permitted.

e. If an entire page is to be deleted, (**the page is torn out and discarded, diagonal lines are drawn through the page and "VOID" is lettered prominently with the reasons**).

f. Field notes are recorded (**at the time of the survey, later in the office**) by a member of the survey crew.

g. Field notes consist of numerical data, explanatory statements, and (**sketches, finished drawings**).

h. The word (**"REPRINT", "COPY"**) should be lettered diagonally across pages that are non-original notes.

Objective 28

Select true statements concerning the arrangement of field notes in the field book by placing an "X" in the blanks next to the true statements.

_____ a. All field books are arranged the same, regardless of the type of survey.

_____ b. Each book should be identified and indexed before recording notes.

_____ c. Left and right hand pages rarely correspond to each other.

_____ d. The symbol used to represent the instrument operator is π.

_____ e. Pages are numbered on each left-hand page. A single page number is used for both the right and left-hand sides.

_____ f. Notes are run down the page, except in route surveys where they are run up the page to conform with sketches.

_____ g. Descriptions and drawings should line up with corresponding numerical data.

_____ h. The left page of notes is generally gridded and is designed for sketches.

_____ i. Column headings on the left page are placed between the first two horizontal lines at the page top and follow from left to right in order of reading and recording.

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Written Test

Objective 29

List one advantage and one disadvantage of electronically recorded notes.

Advantage ____

____

Disadvantage ____

____

Objective 30

Complete the following statements concerning the global positioning system by filling in the blanks with the correct answers.

a. The GPS system was developed, funded, and maintained by the ______________________________.

b. The GPS constellation provides the user with between five and eight usable ______________________ from most points on the earth.

Objective 31

Select true statements about how GPS works by placing an "X" in the blanks next to the true statements.

_____ a. GPS is a two-way ranging system.

_____ b. When a signal is received on the surface of the earth, the time between its transmission and its reception is measured, and the time is then multiplied by the speed of light to obtain the distance.

_____ c. The precise location of the GPS receiver is calculated by a complicated mathematical equation that uses angles and distances from the satellites and two known points to determine the distance between these two known points.

Objective 32

List five benefits of surveying with GPS.

a. ____

b. ____

c. ____

d. ____

e. ____

Objective 33

List four general applications of GPS.

a. ____

b. ____

c. ____

d. ____

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Objective 34

Match the types of GPS procedures with a surveying activity.

1. Point positioning
2. Distance measuring between two points
3. Relative positioning

_____ a. A GPS receiver is placed at an NCS control point and another placed at a point to be located; four satellites must be visible to obtain latitude, longitude, and azimuth between them and elevation of each point.

_____ b. Must start at a known position; the GPS receiver is placed at each point and the satellites are observed for the same amount of time.

_____ c. GPS can be used to locate a point using one GPS receiver; used along long traverses on a route survey; end points are located by GPS and a few in between to tie the traverse into

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a.	10	i.	7	q.	16	y.	31
b.	4	j.	2	r.	21	z.	28
c.	9	k.	13	s.	20	aa.	25
d.	8	l.	17	t.	19	bb.	30
e.	6	m.	14	u.	18	cc.	27
f.	1	n.	11	v.	15	dd.	26
g.	3	o.	24	w.	23	ee.	29
h.	5	p.	22	x.	12		

Objective 2

Answers may be in any order

a. Determination of the shape of the earth and measurement of all facts needed to determine the size, position, shape, and contour of any part of the earth's surface, and the provisions of plans, maps, files and charts recording these facts.
b. Positioning of objects in space, and positioning of physical features, structures, and engineering works on, above, or below the surface of the earth.
c. Determination of the positions of boundaries of public or private land, including national and international boundaries, and registration of those lands with appropriate authorities.
d. Design, establishment, and administration of land and geographic information systems, collection and storage of data within those systems, and analysis and manipulation of that data to produce maps, files, charts and reports for use in the planning and design processes.
e. Planning of the use, development, and re-development of property, and management of that property, whether urban or rural, and whether land or buildings, including determination of values, estimation of costs, and the economic application of resources such as money, labor, and materials taking into account relevant legal, economic, environmental and social factors.
f. Study of the natural and social environment, measurement of land and marine resources, and the use of this data in planning and development in urban, rural, and regional areas.

Objective 3

a, d

Objective 4

a.	11	e.	2	i.	12	m.	8
b.	13	f.	9	j.	3		
c.	1	g.	6	k.	7		
d.	5	h.	10	l.	4		

Objective 5

a. Land Information Systems—Focus is directed toward land records data (land description, land improvements, etc.)
b. Geographic Information Systems—Focus is on a broader range of data

Answers to Written Test

Objective 6

Any six of the following:

a. National Geodetic Survey (NGS)
b. National Ocean Survey (NOS)
c. Bureau of Land Management (BLM)
d. U.S. Geological Survey (USGS)
e. Defense Mapping Agency (DMA)
f. Corps of Engineers
g. U.S. Army
h. National Park Service
i. Department of Transportation

Objective 7

Any three of the following:

a. Horizontal angles
b. Horizontal distances
c. Vertical angles
d. Vertical distances
e. Slope distances

Objective 8

a, c, d

Objective 9

a. Accuracy—Denotes the absolute "nearness" of the measured value to the true value
b. Precision—Refers to the degree of refinement used in measuring a value, either by the number of times measured or by the degree of graduation it was measured in

Objective 10

a, b, c

Objective 11

a. 2
b. 1
c. 3

Objective 12

a. 3
b. 1
c. 5
d. 2
e. 4
f. 8
g. 6
h. 9
i. 10
j. 7

Objective 13

c, d, e

Objective 14

Any four of the following:

a. Triangulation
b. Traversing
c. Grid
d. Azimuth and bearing
e. Latitude and departure

Answers to Written Test

Objective 15

Triangulation—A method of determining positions of points from which horizontal distances can be computed; length of lines are computed trigonometrically from measured base lines and angles

Objective 16

a. intersect
b. azimuths, bearings
c. courses

Objective 17

a, b

Objective 18

Any of the following:

a. 360° – Az N = Bearing
b. Az N – 180° = Bearing
c. 180° + Bearing = Azimuth
d. 360° – Bearing = Azimuth
e. 180° – Bearing = Azimuth

Objective 19

a, b, c, f

Objective 20

a. intersecting
b. vertical
c. below

Objective 21

Leveling—The determination of elevations with a surveying instrument

Objective 22

a. 3
b. 6
c. 4
d. 1
e. 5
f. 2

Objective 23

a. monument
b. sea level

Objective 24

Any four of the following:

a. Laser level
b. Tilting level
c. Dumpy level
d. Automatic level
e. Transit
f. Theodolites
g. Total station
h. Level rods

Objective 25

b, d

Objective 26

b, d

Answers to Written Test

Objective 27

a. permanent
b. upper and lower case
c. hard
d. is not
e. diagonal lines are drawn through the page and "VOID" is lettered prominently with the reasons
f. at the time of the survey
g. sketches
h. "COPY"

Objective 28

b, d, f

Objective 29

Advantage—Any one of the following:

- Will work together with other survey instruments to download collected data
- Data may be transferred from field to office with ease
- Free up survey to have extra time for sketches and other non-numerical functions

Disadvantage—Potential for this form of data collection not being accepted in a court of law

Objective 30

a. U.S. Department of Defense
b. satellites

Objective 31

b, c

Objective 32

Any five of the following:

a. Better accuracy than conventional surveying systems
b. Less room for error
c. Requires fewer personnel; one person unit
d. Not affected by weather; stays on schedule
e. Not affected by time constraints; runs 24 hours a day
f. Takes less time than conventional methods
g. Capable of providing both horizontal and vertical coordinates
h. Does not disturb the landscape

Objective 33

Any four of the following:

a. First order triangulation points
b. Control points on government surveys
c. Aerial survey control
d. Route surveys
e. Projects with isolated control points
f. GPS data converts to various types of coordinate systems

Objective 34

a. 3
b. 2
c. 1

Unit 6 Interpretation of Surveyor's Notations

Prerequisites:
Units 1 through 5

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 8, and Student Supplement 1.

☐ 4. **Study** Information Sheet, Objectives 9 through 11, and Student Supplement 2.

☐ 5. **Study** Information Sheet, Objectives 12 through 18.

☐ 6. **Do** Assignment Sheet 2, "Convert Azimuths to Bearings and Bearings to Azimuths."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat steps 5 through 7.

☐ 8. **Study** Information Sheet, Objective 19.

☐ 9. **Do** Assignment Sheet 1, "Plot Lines and Distances Using Several Methods."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat steps 8-10.

☐ 11. **Do** Assignment Sheet 3, "Lay Out a Closed Traverse."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, repeat steps 11 and 12.

☐ 13. **Do** Assignment Sheet 4, "Complete a Mathematical Closure of a Traverse."

Learning Activities Sheet

☐ 14. **Study** Information Sheet, Objectives 20 through 29.

☐ 15. **Do** Assignment Sheet 5, "Reduce Four Types of Field Notes."

☐ 16. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat steps 14 through 16.

☐ 17. **Study** Information Sheet, Objectives 30 through 34.

☐ 18. **Do** Assignment Sheet 6, "Draw a Map Using Bearings, Distances, and Coordinates."

☐ 19. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 18 and 19.

☐ 20. **Go** To computer and complete Assignment Sheet 7, "Lay Out the Property Boundary For the MAVCC Topographic Survey Map."

☐ 21. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 22. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 20 and 21.

☐ 22. **Check** With instructor for any additional assignments to be completed.

☐ 23. **Do** Additional assignments listed below.

____

____

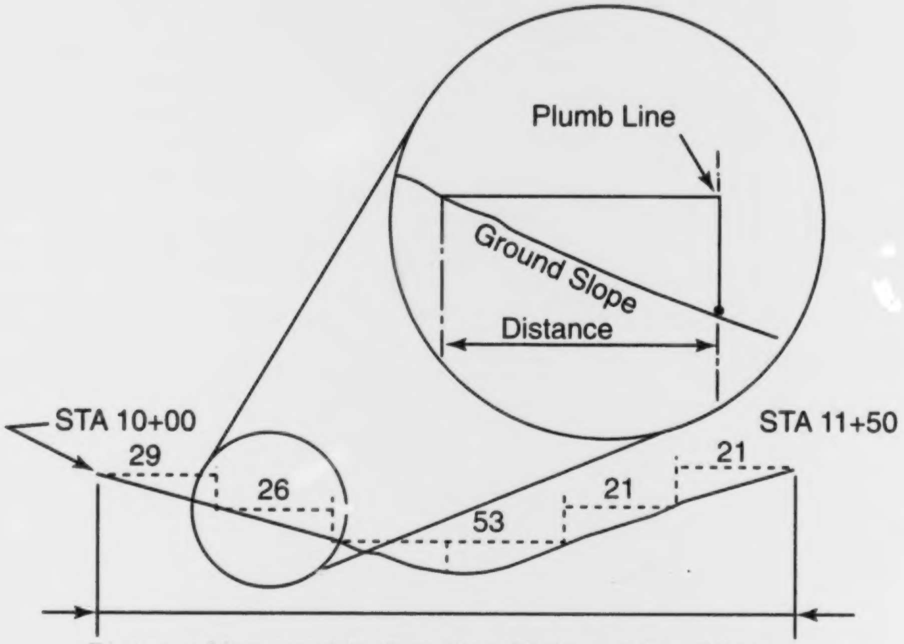
____

☐ 24. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 25. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

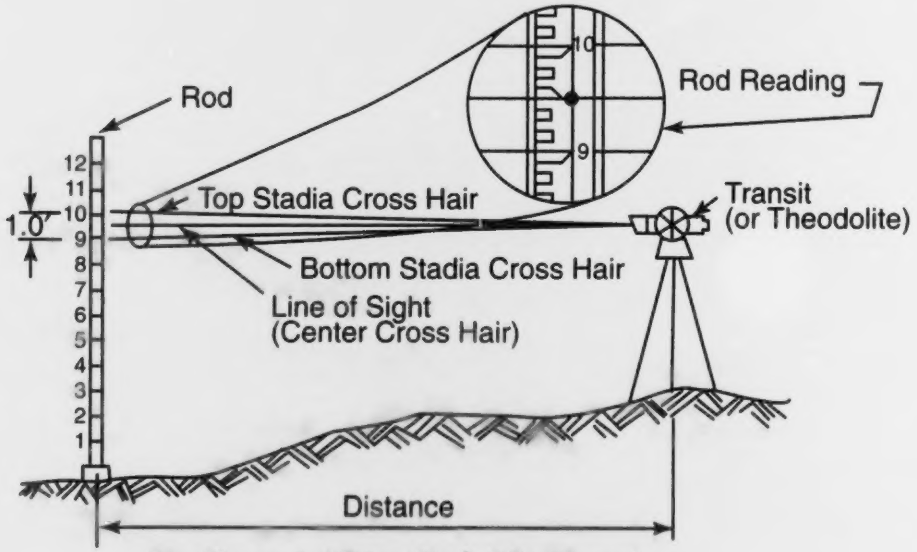
***Permission to duplicate this form is granted.**

Measuring Horizontal Distances


Plumb Line
Ground Slope
Distance
STA 10+00
STA 11+50
29
26
53
21
21

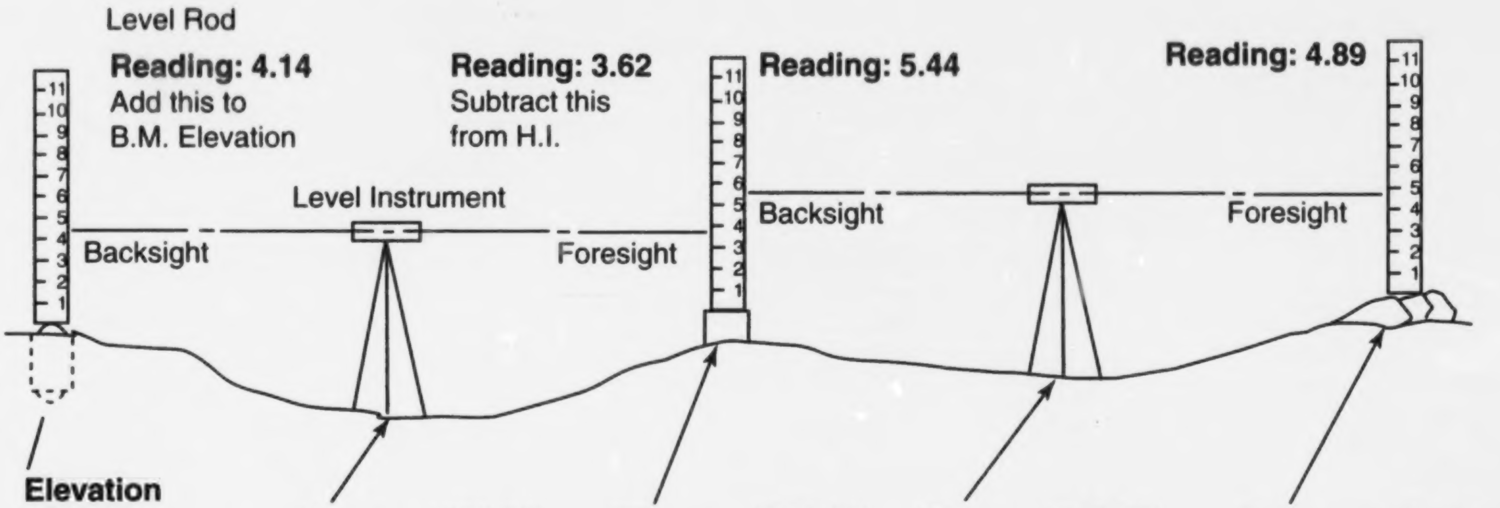
Distance Measured by Breaking Chain and Plumbing

Direct Method — Taping


Rod
Rod Reading
10
9
12
11
10
9
8
7
6
5
4
3
2
1
1.0'
Top Stadia Cross Hair
Transit
(or Theodolite)
Bottom Stadia Cross Hair
Line of Sight
(Center Cross Hair)
Distance

Indirect (Stadia) Method

Finding an Elevation With a Level and a Rod


Level Rod
Reading: 4.14
Add this to
B.M. Elevation
Reading: 3.62
Subtract this
from H.I.
Reading: 5.44
Reading: 4.89
Level Instrument
Backsight
Foresight
Backsight
Foresight
11
10
9
8
7
6
5
4
3
2
1

Elevation
1000.00′
USGS BM
Beginning Point

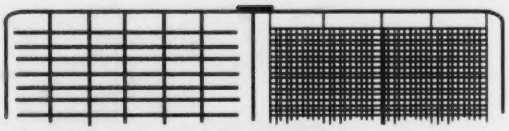
H.I. = 1000.00′
+ 4.14
1004.14′

TP1 = 1004.14′
+ 3.62
1000.52′

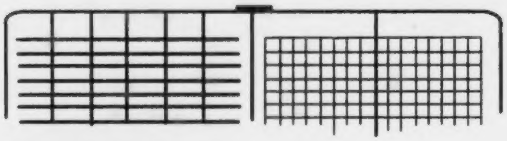
H.I. = 1000.52′
+ 5.44
1005.96′

TP2 = 1005.96′
+ 4.89
1001.07′

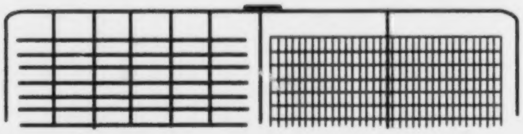
Styles of Field Note Paper



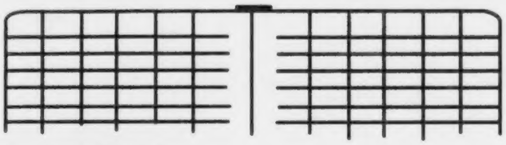
Engineer's Field Book
Left page: Blue horizontal lines; red vertical lines. Right page: 10 x 10 blue lines; red vertical center line. Inch lines heavy.



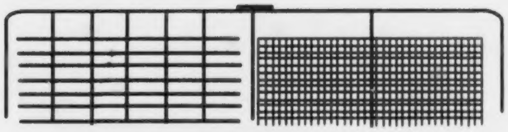
Field Book
Left page: Blue horizontal lines; red vertical lines. Right page: 4 x 4 blue line; red vertical center line.



Transit Field Book
Left page: Blue horizontal lines; red vertical lines. Right page: 8 vertical lines and 4 horizontal blue lines; red vertical center line.



Level Book
Both pages: Blue horizontal lines; red vertical lines. 6 vertical columns.



Mining Transit Book
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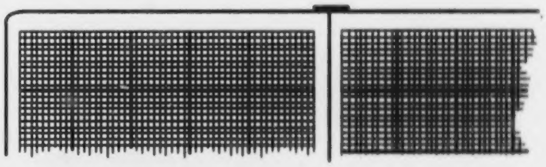
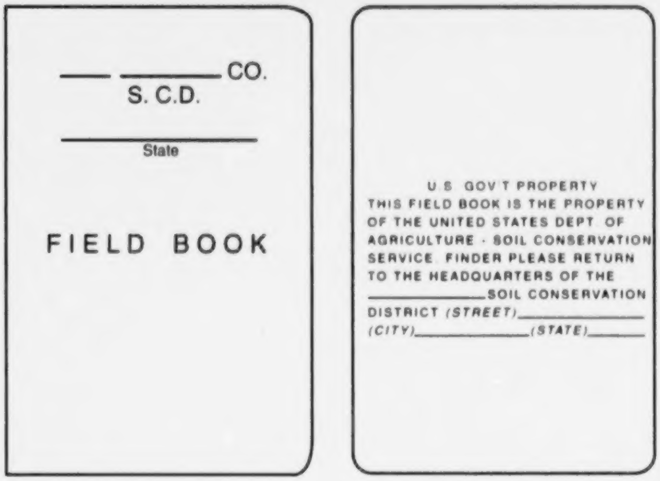


Cross Section Book
Both pages: 10 x 10 blue lines; inch lines slightly heavier.

Initializing a Field Book

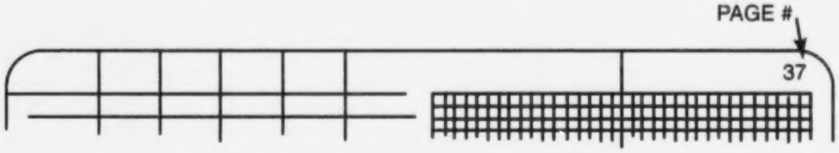


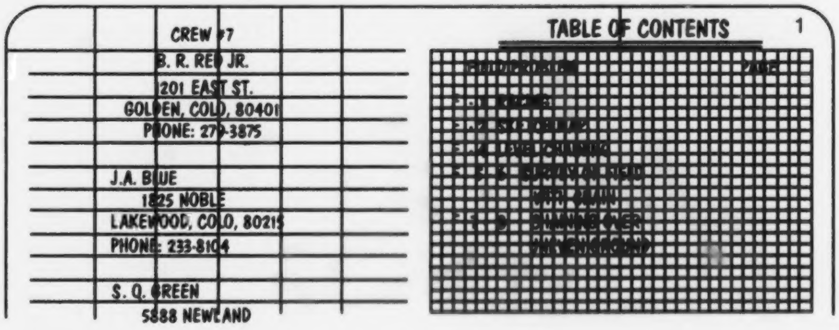
____ ________ CO.
S. C. D.

____
State

FIELD BOOK

U.S. GOV'T PROPERTY
THIS FIELD BOOK IS THE PROPERTY OF THE UNITED STATES DEPT. OF AGRICULTURE - SOIL CONSERVATION SERVICE. FINDER PLEASE RETURN TO THE HEADQUARTERS OF THE ________ SOIL CONSERVATION DISTRICT *(STREET)* ________
(CITY) ________ *(STATE)* ________





CREW #7
B. R. RED JR.
1201 EAST ST.
GOLDEN, COLO, 80401
PHONE: 279-3875

J.A. BLUE
1825 NOBLE
LAKEWOOD, COLO, 80215
PHONE: 233-8104

S. Q. GREEN
5888 NEWLAND

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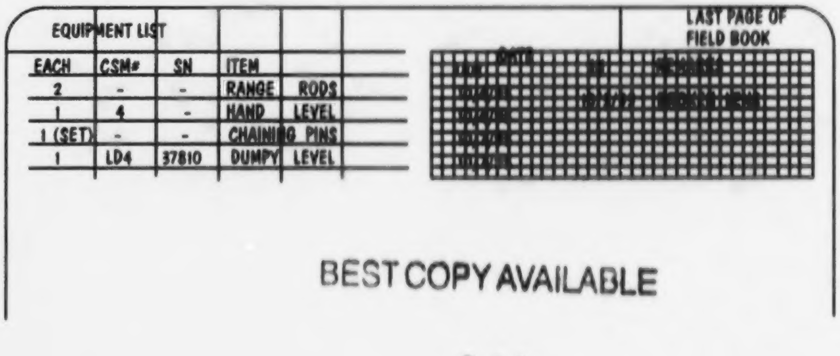


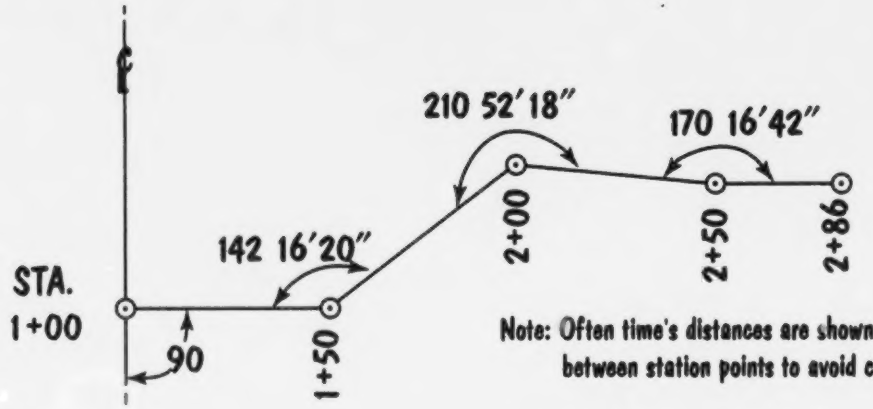
EQUIPMENT LIST

EACH	CSM#	SN	ITEM
2	-	-	RANGE RODS
1	4	-	HAND LEVEL
1 (SET)	-	-	CHAINING PINS
1	LD4	37810	DUMPY LEVEL

LAST PAGE OF
FIELD BOOK

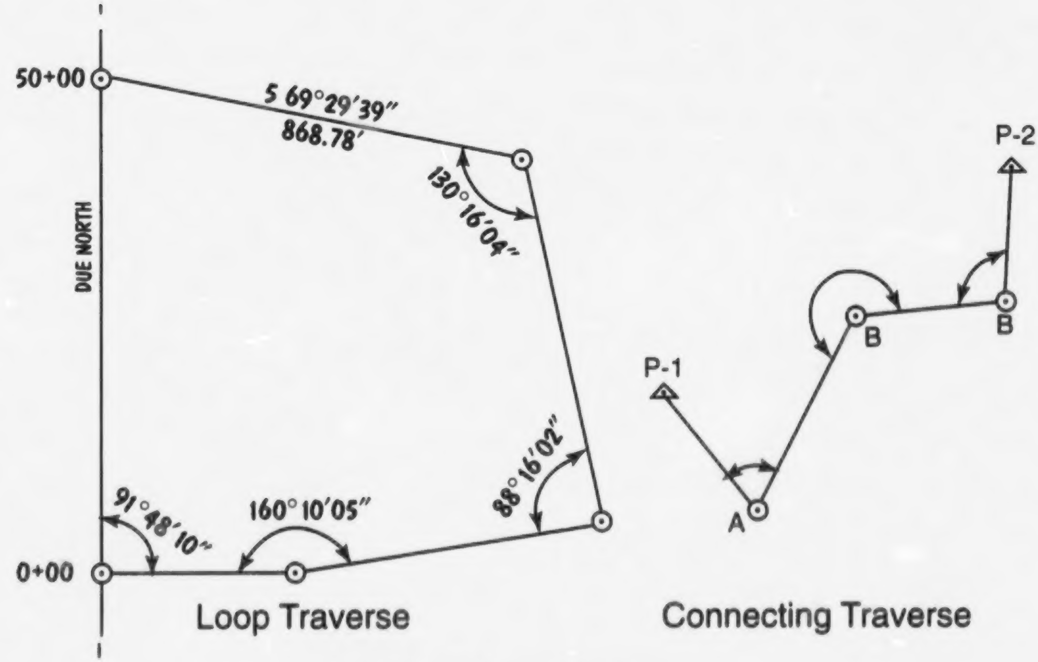
BEST COPY AVAILABLE

Types of Traverses


℄
210 52′18″
170 16′42″
142 16′20″
STA.
1+00
90
1+50
2+00
2+50
2+86

Note: Often time's distances are shown between station points to avoid confusion.

Open Traverse


50+00
5 69°29′39″
868.78′
130°16′04″
DUE NORTH
88°16′02″
91°48′10″
160°10′05″
0+00
P-2
B
B
P-1
A

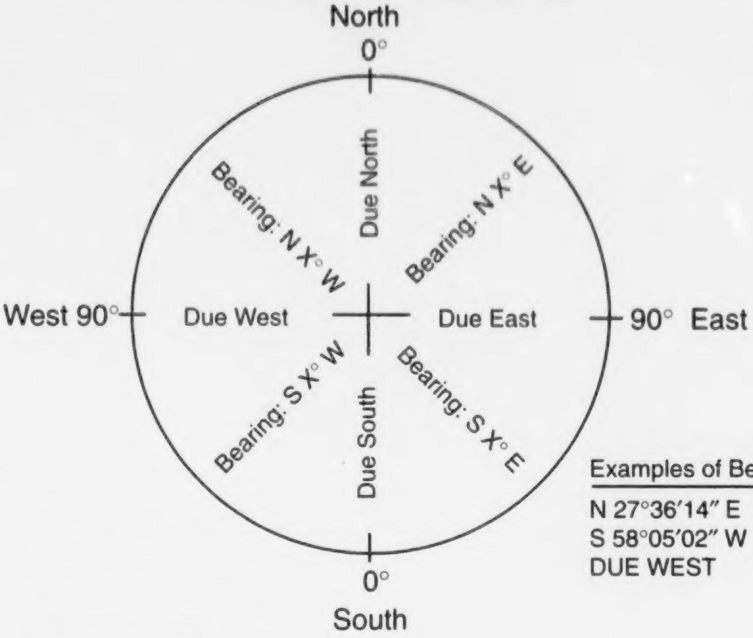
Loop Traverse

Connecting Traverse

Closed Traverses

Direction by Bearing or Azimuth

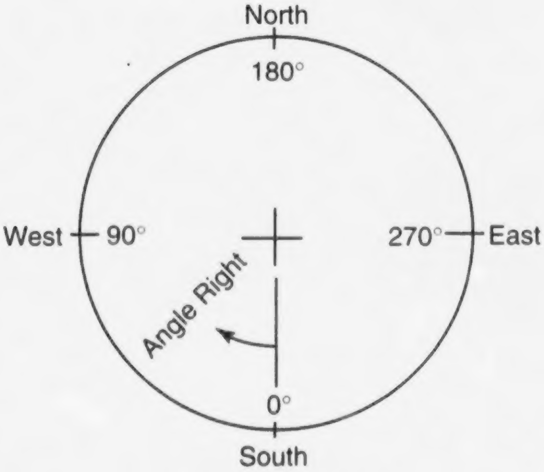
Direction by Bearing


North
0°
Due North
Bearing: N X° W
Bearing: N X° E
West 90°
Due West
Due East
90° East
Bearing: S X° W
Bearing: S X° E
Due South
0°
South

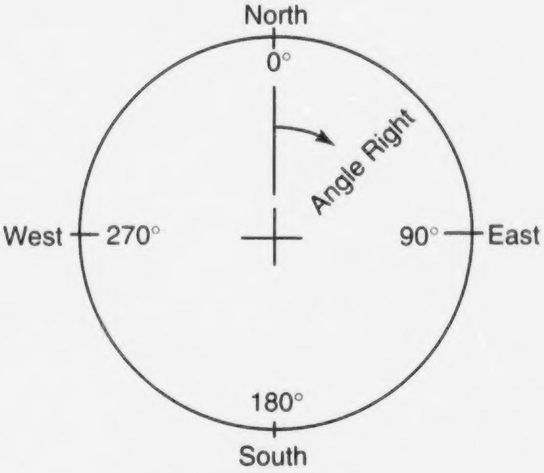
Examples of Bearings:

N 27°36′14″ E
S 58°05′02″ W
DUE WEST

Direction by Azimuth

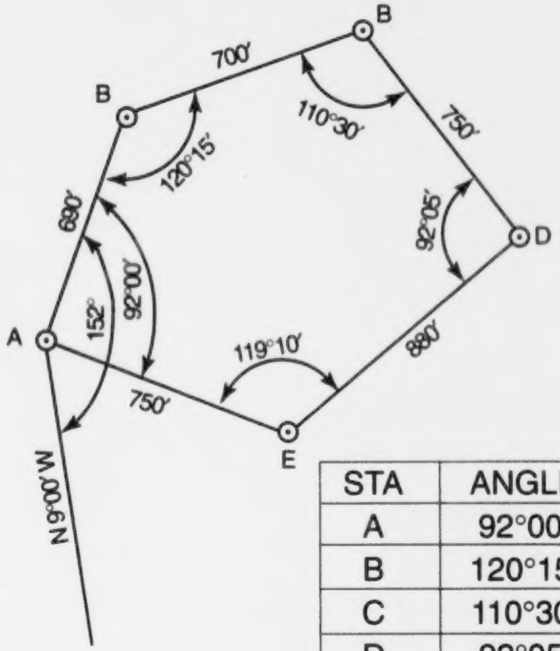

North
180°
West
90°
270°
East
Angle Right
0°
South

Azimuth South (Az_S)
Example: $Az_S = 246°07′53″$


North
0°
Angle Right
West
270°
90°
East
180°
South

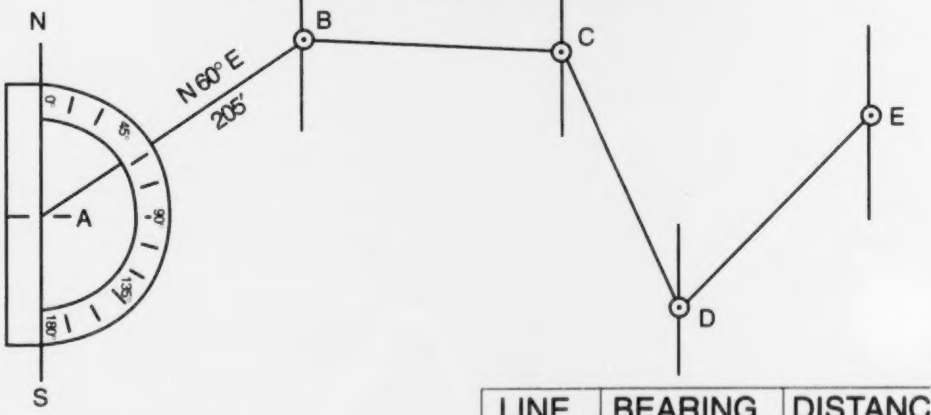
Azimuth North (Az_N)
Example: $Az_N = 66°07′53″$

Methods for Plotting Traverses


B
700'
B
110°30'
750'
120°15'
690'
92°05'
D
A
152°
92°00'
119°10'
880'
750'
E
N 9°00' W

STA	ANGLE	COURSE	DIST
A	92°00'	AB	690'
B	120°15'	BC	700'
C	110°30'	CD	750'
D	92°05'	DE	880'
E	119°10'	EA	750'

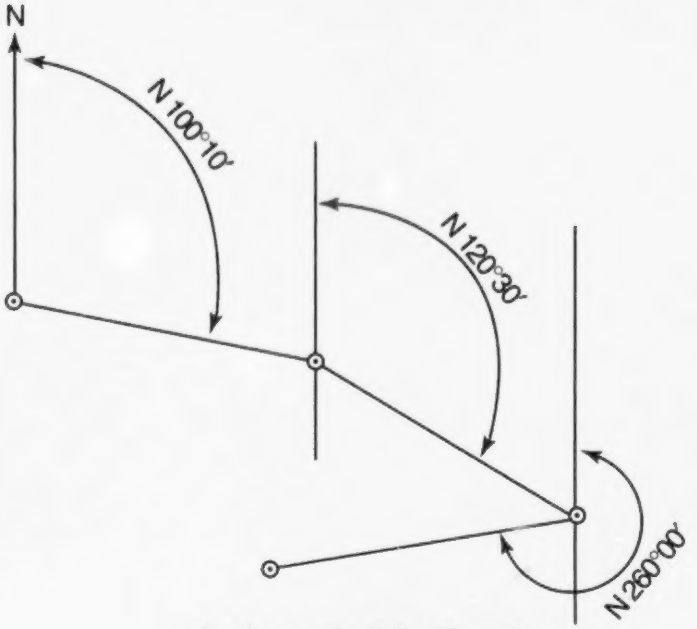
Interior Angles Method


N
B
C
N 60° E
205'
E
0
45
90
135
180
A
D
S

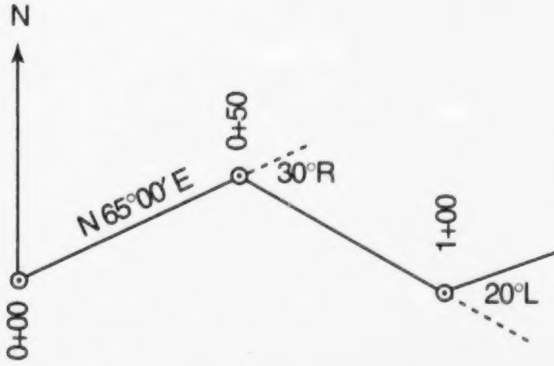
LINE	BEARING	DISTANCE
AB	N 60° E	205'
BC	S 88° E	175'
CD	S 30° E	180'
DE	N 45° E	170'

Distance and Bearing Method

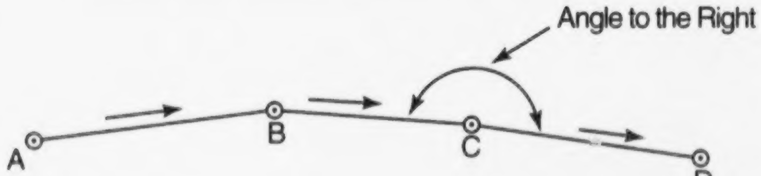
Methods for Plotting Traverses (continued)


N
N 100°10′
N 120°30′
N 260°00′

Azimuth Method

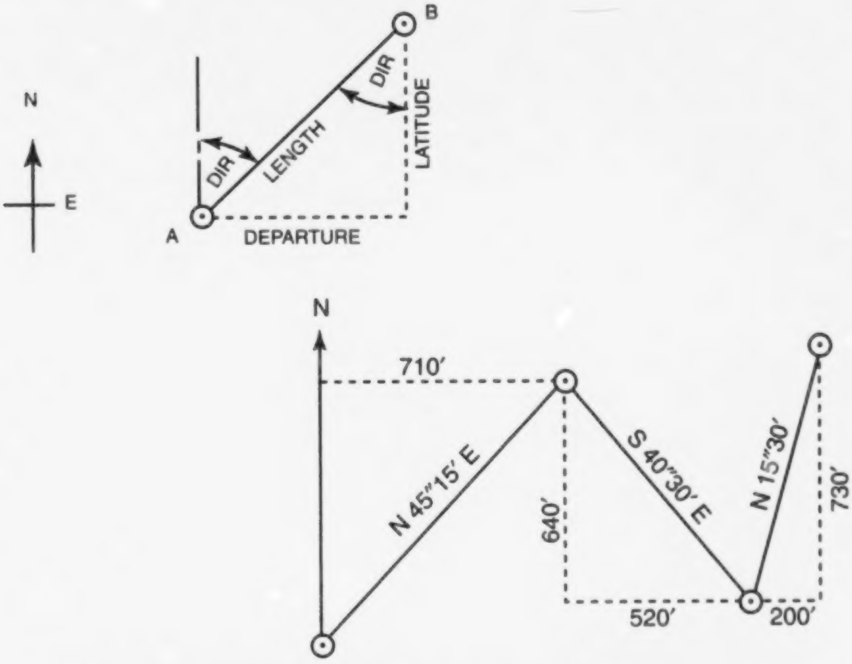

N
N 65°00′ E
0+00
0+50
30°R
1+00
20°L
1+90

Deflection Angles Method

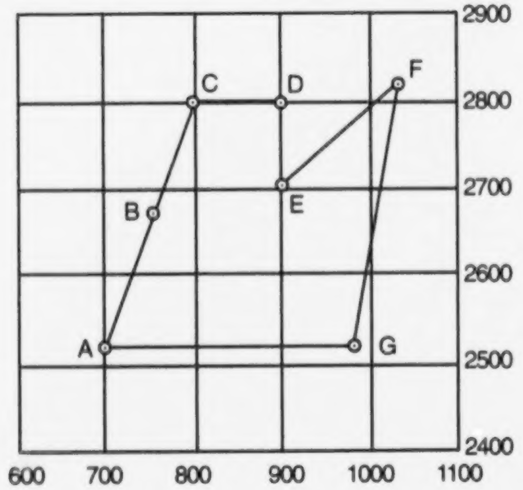

Angle to the Right
A
B
C
D

Angles-to-the-Right Method

Methods for Plotting Traverses (continued)


N
E
A
B
DIR
LENGTH
DIR
LATITUDE
DEPARTURE
N
710′
N 45″15′ E
S 40″30′ E
N 15″30′
640′
730′
520′
200′

Latitudes and Departures Method



STA	X-COORD	Y-COORD
A	700	2519
B	750	2672
C	800	2800
D	900	2800
E	900	2700
F	1034	2819
G	981	2519

Rectangular Coordinates Method

TM 9

Unit Contents

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Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Obtain aerial photos for the USGS quad map of your local area.
- Obtain a digital terrain map of your local area.
- Call or write to the NCIC Headquarters/USGS for information on how to order topographic maps for your area.

  NCIC Headquarters
  National Cartographic Information Center
  U.S. Geological Survey
  507 National Center
  Reston, VA 22092
  703/860-6045

- Take a field trip and identify contour configurations on the ground.
- Choose an area around the school and prepare an isometric sketch of the terrain.
- Show examples of aerial photographs, orthophotographs, and stereo models. Contact a local engineering firm and inquire if they are using the new digital imagery in their mapping program.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- Brinker, Russell C. and Paul R. Wolf. *Elementary Surveying*, 9th ed. New Jersey: Prentice-Hall, Inc., 1998.
- Colley, Barbara C. *Practical Manual of Land Development*, 3rd ed. New York: McGraw-Hill, Inc., 1998.
- *Definitions of Surveying and Associated Terms.* American Congress on Surveying and Mapping and the American Society of Civil Engineers.
- Fundamental Training Manual, Advantage Series 13. Dubuque, IA, Eagle Point Software, 1995.
- Surveying Tutorials, Eagle Point Software
  4131 Westmark Drive
  Dubuque, IA 52002-2627
  1-800-678-6565
  www.eaglepoint.com
- *Glossaries of BLM Surveying and Mapping Terms*, 2nd ed. Bureau of Land Management U.S. Department of the Interior.
- *Map Drafting and Related Computations for Plane Surveying: Field Book*. Natchitoches, LA: Vocational Curriculum Development and Research Center.
- *Map Reading*, FM 21-26. Department of Defense/Department of the Army Field Manual. Washington, DC: Government Printing Office.
- LDD–Civil Software, Autodesk, Inc.
  San Rafael, CA
  1-800-964-6432
  www.autodesk.com
- Thompson, Morris M. *Maps for America*, 3rd ed. USGS, United States Department of the Interior, 1987. (Out of print)

Answers to Assignment Sheets

Assignment Sheet 1

Use a Polar Planimeter to Determine Acreage

Problem 1		Problem 2	
a.	4,000,000 sq. ft.	a.	4,000,000 sq. ft.
b.	1.2 sq. inches	b.	1.12 sq. inches
c.	4,800,000 sq. ft.	c.	4,480,000 sq. ft.
d.	110.19 acres	d.	102.8 acres

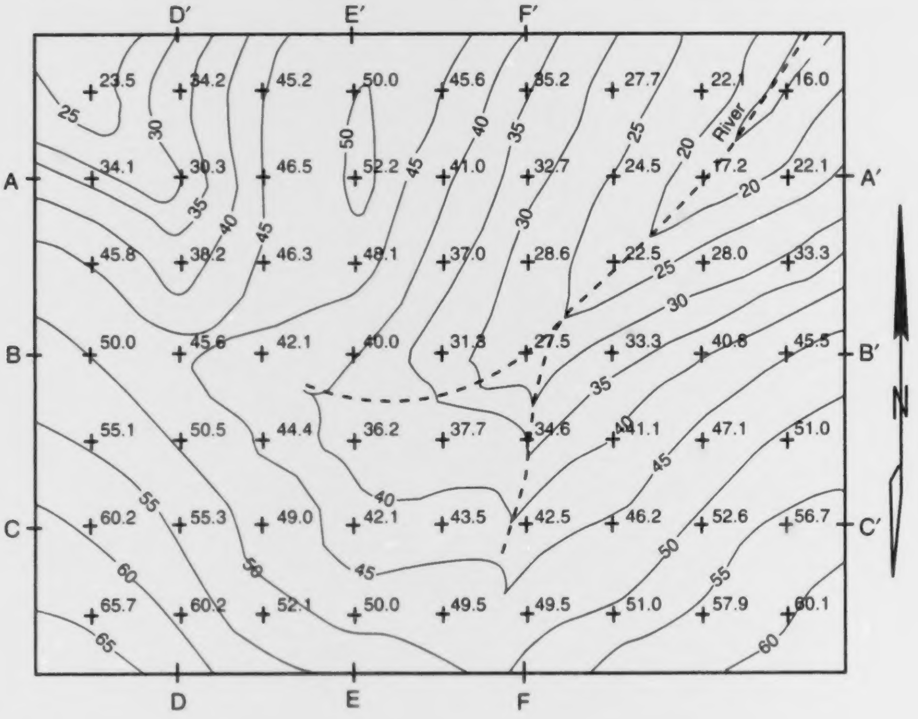
Note: Answers may deviate due to paper shrinkage

Problem 3	Problem 4
Determined by instructor	Determined by instructor

Assignment Sheet 2

Interpolate Contours From a Grid Survey and Prepare Profiles From the Contour Map

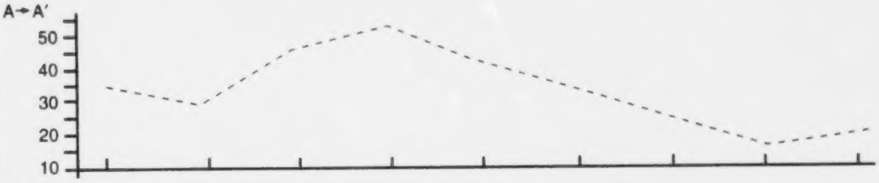
Part 1

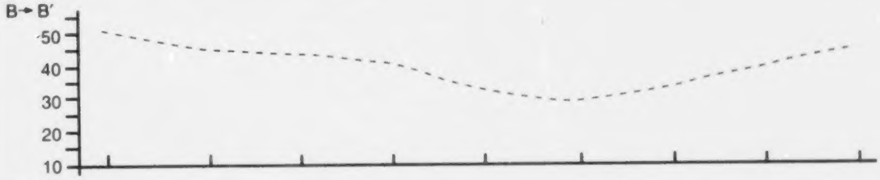


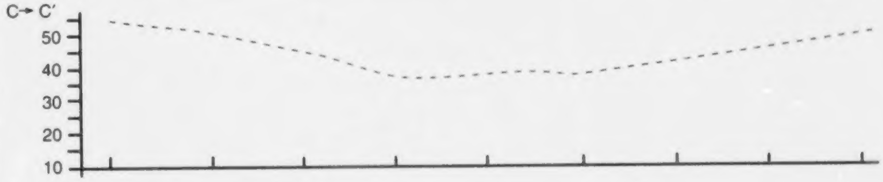
D'
E'
F'
A
A'
B
B'
C
C'
D
E
F
N
River
23.5
34.2
45.2
50.0
45.6
35.2
27.7
22.1
16.0
34.1
30.3
46.5
52.2
41.0
32.7
24.5
17.2
22.1
45.8
38.2
46.3
48.1
37.0
28.6
22.5
28.0
33.3
50.0
45.6
42.1
40.0
31.3
27.5
33.3
40.8
45.5
55.1
50.5
44.4
36.2
37.7
34.6
41.1
47.1
51.0
60.2
55.3
49.0
42.1
43.5
42.5
46.2
52.6
56.7
65.7
60.2
52.1
50.0
49.5
49.5
51.0
57.9
60.1
25
30
35
40
45
50
55
60
65
20

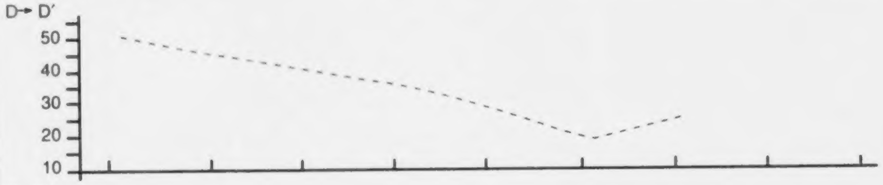
Answers to Assignment Sheets

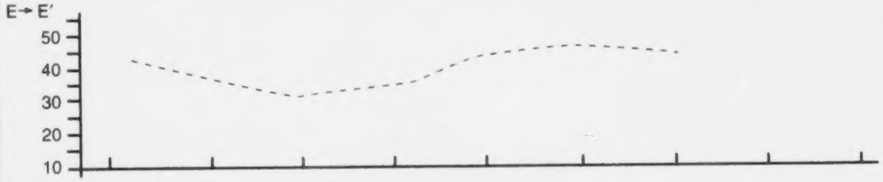
Part 2

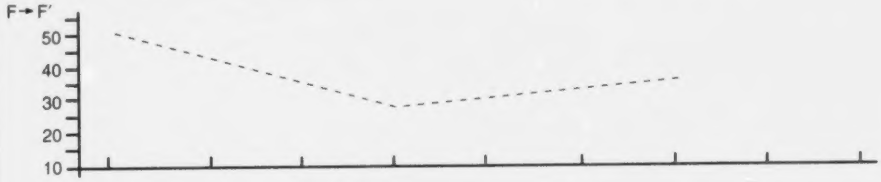












Assignment Sheet 3

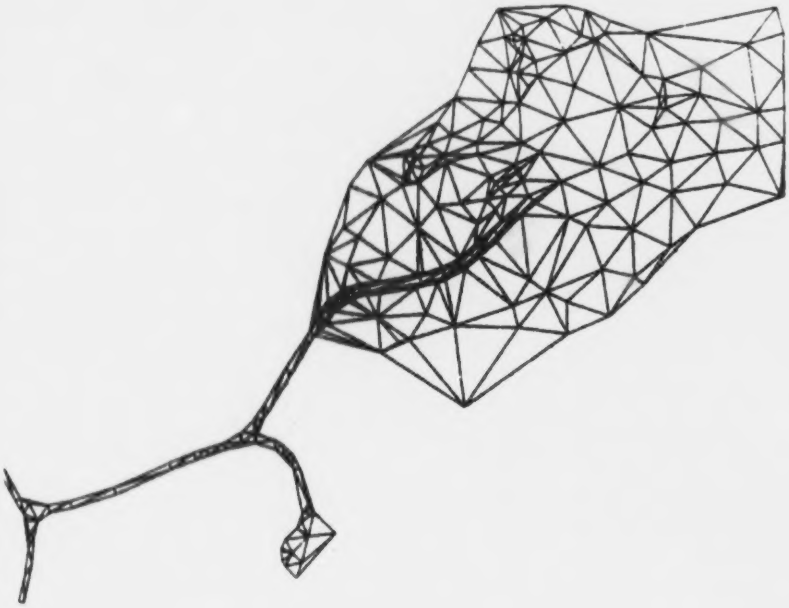
Calculate Grades

a. 53%
b. 185%
c. 138%
d. 17%
e. 32%

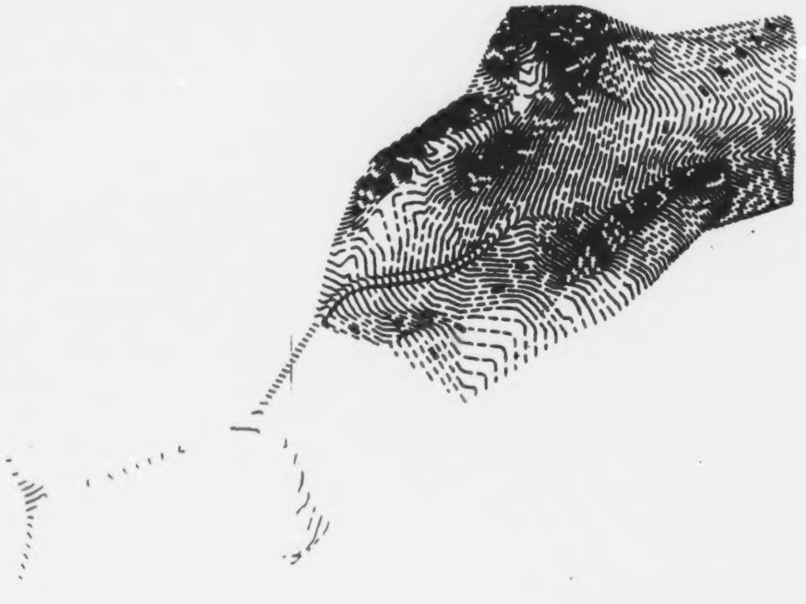
Assignment Sheet 4

Build a TIN and Make Contours

TIN Drawing



Contour Drawing



Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match terms related to topographic mapping with their definitions. Definitions continue on the next page.

1. Aerial photograph
2. Backsight
3. Contour
4. Contour grading
5. Contour interpolation
6. Contour interval
7. Control point
8. Cross section
9. Cut and fill
10. Datum
11. Depression contour lines
12. Foresight
13. Grade
14. Gradient
15. Grading plan
16. Index contour line
17. Intermediate contour lines
18. Photogrammetric surveying
19. Planimeter
20. Profile
21. Sea level
22. Slope
23. Spot elevation
24. Stadia
25. Stereoplotter
26. Stereoscope
27. Stereoscopic model
28. Stereovision
29. Supplemental contour lines
30. Topographic map
31. Topography

_____ a. Every 5th contour line, which is numbered

_____ b. An imaginary line on the ground, all points of which are at the same elevation above or below a specified datum surface, usually mean sea level

_____ c. Refers to distance and elevation measurements that have been obtained by surveying methods

_____ d. A road construction term that describes the quantities of earth removed from hillsides and filled into low spots

_____ e. A survey reading taken on a point of known elevation for the purpose of obtaining the height of the instrument; also called a plus (+) sight

_____ f. A plane that cuts through at right angles to the horizontal; also refers to a drawing of this plane

_____ g. Any numerical or geometrical quantity or set of such quantities that serves as a reference or base for other quantities

_____ h. Indicate an elevation that represents a low place on the ground that has no surface drainage

_____ i. A photograph taken from an airborne vehicle

_____ j. Instrument for measuring plane areas

_____ k. Represent half intervals between contour lines

_____ l. A piece of equipment that allows the operator to view the stereo model in 3-dimension; from this model topographic and planimetric information can be traced out for future development of a map

_____ m. Configuration of the land surface; the graphic delineation or portrayal of that configuration in map form, as by contour lines; in oceanography the term is applied to a surface such as the sea bottom or a surface of given characteristics within the water mass

_____ n. A plan containing original ground contours over which contours of the highway, subdivision, or other embankment or excavation to be completed are superimposed on and connected with the original ground contours at the edge of construction limits

_____ o. Method of design using proposed finished contours; may be used for determination of earthwork

_____ p. The rate of grade

_____ q. Contour lines that are between index contours

_____ r. Degree of rise or fall of a line with reference to the vertical and horizontal planes

_____ s. The area covered by two overlapping or stereo pair of photos

_____ t. Line representing a longitudinal, vertical section through a roadway or pipeline

_____ u. Determination of an intermediate value between field values from some known or assumed rate; estimating of contours

_____ v. A survey reading taken on a new point to determine its elevation; also called a minus (-) sight

_____ w. The vertical distance between the planes of consecutive contour lines, such as 5, 10, 20, 100, or 200

_____ x. A point on a map or chart whose height above a specified reference datum is noted, usually by a small "x" elevation value

_____ y. The science of obtaining measurements by means of photographs, usually aerial photographs

_____ z. Any station in a horizontal or vertical control network that is identified in a data set or photograph and used for correlating the data shown in that data set or photograph

_____ aa. An established elevation of the ground or a road surface; the amount of incline or slope from the horizontal expressed usually in percentages

_____ bb. Topographic datum line which is the level between high and low tide

_____ cc. A pocket size stereoviewer consisting of two magnifying lenses in a metal frame that allows ease in viewing aerial photographs without having to use a stereoplotter

_____ dd. A line and symbol representation of natural and selected manmade features of a part of the earth's surface plotted to a definite scale; distinguishing characteristic is the portrayal of the shape and elevation of the terrain by contour lines

_____ ee. The ability to see three-dimensionally (length, width, and depth at the same time) using two views of a single object from two slightly different positions

Objective 2

Define topographic analysis.

____

____

Objective 3

List three types of maps that show relief.

a. ____

b. ____

c. ____

Objective 4

List six uses of topographic maps.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

Written Test

Objective 5

Define topographic survey.

____

____

____

Objective 6

Distinguish between types of surveys used in topographic mapping by placing an "X" next to the description of an aerial survey.

_____ a. Used for large scale maps of small areas less than 160 acres

_____ b. Used for mapping projects covering large areas more than 100 acres

Objective 7

Match field methods for locating topographic details, planimetric features, and contours with their descriptions.

1. Radiation by total station data collector
2. Radiation by stadia
3. Coordinate squares or grid method
4. Offsets from a reference
5. Plane table method
6. Topographic detail with a portable global positioning system (GPS)

_____ a. Better suited for locating contours than planimetric features; theodolite or transit may be used to lay out control lines at right angles to each other

_____ b. One of the oldest methods of surveying and seldom used today; compiled directly in the field on a drawing board mounted on a tripod with an alidade mounted on the board

_____ c. A new satellite-based surveying procedure; can compute in real time the coordinate locations of where the receiver is placed

_____ d. Based on the principle that in similar triangle, corresponding sides are proportional

_____ e. A distance and a horizontal angle or azimuth are measured to each topographic detail point

_____ f. Most often used for mapping long linear areas such as route surveys

Objective 8

List six factors affecting the selection of the field method to be used for a topographic survey.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Objective 9

Distinguish between controls for topographic surveys by placing an "X" next to the description(s) of horizontal controls.

_____ a. Is established by lines of levels starting from and closing on benchmarks; elevations are established for all traverse hubs

_____ b. Is established by traversing, triangulation, trilateration, and inertial and satellite methods depending on the size of the land area

_____ c. Is provided by two or more points on the ground, precisely fixed in position by distance and direction

Objective 10

Select true statements concerning characteristics of benchmarks by placing an "X" in the blanks next to the true statements.

_____ a. Is a horizontal reference point, whose elevation above and below an adopted elevation is known

_____ b. Is a copper disk set in concrete and tied to mean sea level

_____ c. Elevations are measured at the top of the marker

_____ d. On maps they are shown as small circles; corresponding elevation usually labeled inside circle with BM annotation

Objective 11

Arrange in order the steps in laying out a topographic map by placing the correct sequence numbers (1-5) in the appropriate blanks.

_____ a. Calculate latitudes and departures, adjust traverse, and calculate coordinates.

_____ b. From the points located by the horizontal control traverse, make a survey locating all the details of features to be shown.

_____ c. Run an accurate closed traverse within the area to be mapped.

_____ d. Establish contours from vertical control.

_____ e. Using the coordinates, plot the traverse.

Written Test

Objective 12

Define digital elevation model.

____

____

____

Objective 13

Describe the two basic geometric configurations that are used in the field for collecting DEM data.

a. Grid method: ______________________________________

____

____

b. Irregular method: __________________________________

____

____

Objective 14

Define breaklines.

____

____

Objective 15

Select true statements about the characteristics of a triangulated irregular network (TIN) by placing an "X" in the blanks next to the true statements.

_____ a. TIN models are created from a multiple array of surveyed points.

_____ b. A TIN model is constructed by connecting points in the array to create a network of adjoining triangles.

_____ c. The most common TIN is a network of equilateral triangles.

_____ d. Contours are stationary only at triangle boundaries.

_____ e. TIN created for automated contouring must have field points selected carefully, breaklines identified, and data properly inputted in order to create a good output.

Objective 16

Complete the following statements concerning national standards for accuracy on topographic maps by circling the correct measurements.

a. Horizontal accuracy—Requires no more than 10 percent of well-defined map points tested to be more than (**$^1/_{10}$″**, **$^1/_{50}$″**) out of correct position at publication scales

b. Vertical accuracy—Requires that no more than 10 percent of the elevations of test points interpolated from contours be in error more than (**$^1/_2$**, **$^1/_3$**, **$^1/_{10}$**) the contour interval

Objective 17

Complete the following chart of scale ratios used in the USGS topographic series.

	Series	Scale	One Inch Represents	Standard Quadrangle Size (latitude & longitude)	Quadrangle Area (square miles)
a.	7.5-minute	______	2,000 feet	7.5 x 7.5 min.	49 to 71
b.	15-minute	1:62,500	______	15 x 15 min.	197 to 282
c.	Intermediate-scale quadrangle	______	over 1.5 miles	30 min. x 1°	1,145 to 2,167
d.	U.S. 1:250,000[3]	1:250,000	about 4 miles	______	4,580 to 8,669
e.	International Map of the World	______	about 16 miles	4° x 6°	73,734 to 102,759

Objective 18

Select true statements concerning the selection of contour intervals by placing an "X" in the blanks next to the true statements.

_____ a. The standard of accuracy required affects the selection of a contour interval.

_____ b. Rugged terrain requires a larger contour interval.

_____ c. If map scale is reduced, the contour interval is reduced.

_____ d. 10-foot and 100-foot intervals are rarely used.

_____ e. USGS commonly uses 5 foot contour intervals.

_____ f. Defense Mapping Service (DMS) commonly uses 50 foot contour intervals.

_____ g. Common rule on contour intervals is not to show more than 1 contour per linear inch.

Objective 19

Complete the following statements concerning characteristics of contour lines by circling the correct words.

a. A contour is a line, all points of which lie at equal (**elevations, distances from a benchmark**).

b. Every contour closes upon itself (**within, without, within or without**) the limits of the map.

c. A contour line closing within the limits of the map either indicates a summit or a (**river, depression**).

d. Contours never cross each other, except in the case of a/an (**mountain, overhanging cliff**) or a cave, and then they must cross twice.

e. On uniform slopes, contours are (**evenly, unevenly**) spaced.

f. The sharpest bends in contours occur at their intersection with ridge and valley lines, which they cross at (**45°, right**) angles.

g. Contours bend toward the (**upgrade, downgrade**) when crossing a valley or depression, and toward the (**upgrade, downgrade**) when crossing a ridge line.

h. Contours crossing a railroad laid to an (**even, uneven**) grade will be spaced at equal intervals.

i. Contour lines crossing a stream point (**upstream, downstream**) and form V's or U's.

j. Contour lines (**can, cannot**) run into the shore of a lake or other still body of water since the water is at the same level at all points.

k. It is customary to make every fifth contour line (**dashed, heavier**) than the rest. The line is broken at some convenient place and the number representing the elevation is inserted. When contour lines are far apart, each one may be numbered.

Objective 20

Complete the following statements about the characteristics of hachures by circling the correct words.

a. A hachure is a series of (**dotted, short**) lines drawn in the direction of the slope.

b. On a steep slope, the hachure lines are (**heavy, light**) and spaced close together.

c. Hachure lines (**do not give, give**) actual elevations of the ground.

d. Hachure lines give a (**specific, general**) impression of the ground configuration.

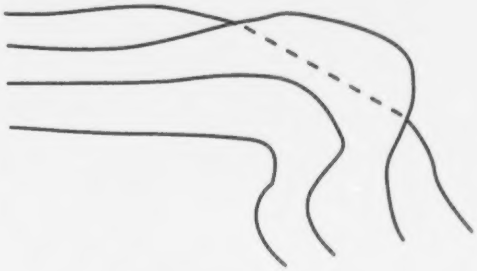
e. Contour depressions are shown by hachure symbols shown as short ticks at right angles to the contour, pointing towards the (**top, center**) of the depression.

Objective 21

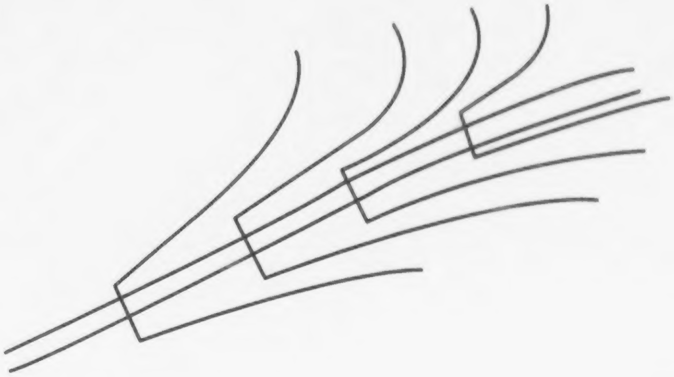
Match contour line features with their configurations.

1. Stream
2. Embankment
3. Dam
4. Steep terrain
5. Flat terrain
6. Saddle
7. Depression contour
8. Overhang or cliff
9. Index contour
10. Intermediate contour

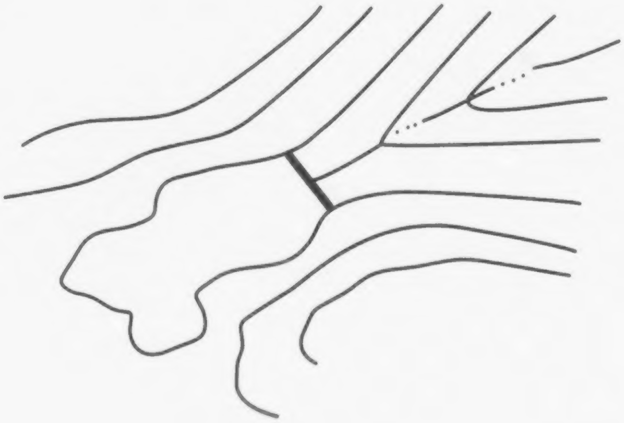
_____ a.



_____ b.

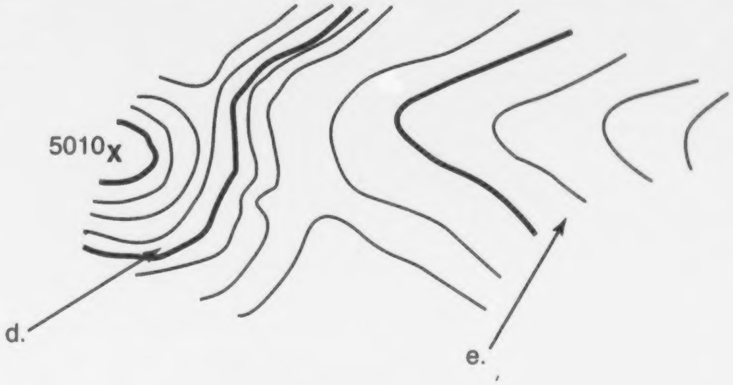


_____ c.



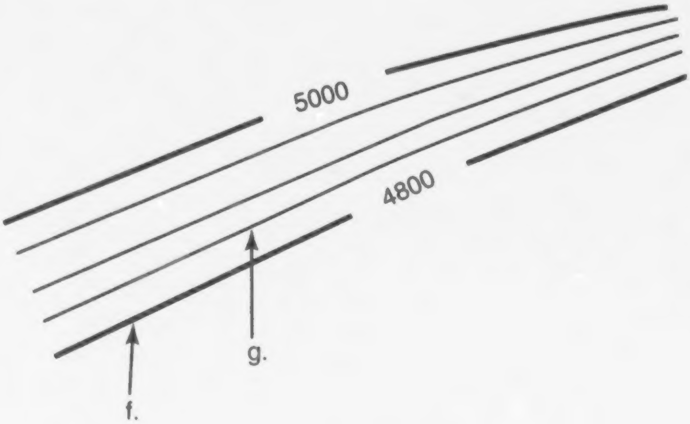
_____ d.

_____ e.

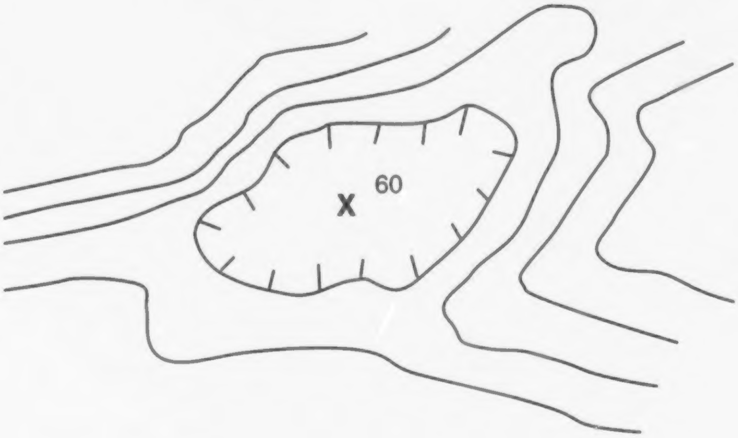


_____ f.

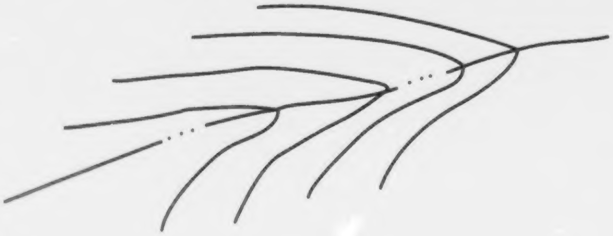
_____ g.


5000
4800
f.
g.

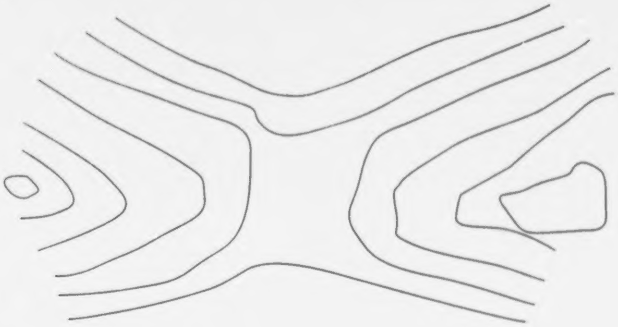
_____ h.



_____ i.



_____ j.



*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a.	16	k.	29	u.	5	ee.	28
b.	3	l.	25	v.	12		
c.	24	m.	31	w.	6		
d.	9	n.	15	x.	23		
e.	2	o.	4	y.	18		
f.	8	p.	14	z.	7		
g.	10	q.	17	aa.	13		
h.	11	r.	22	bb.	21		
i.	1	s.	27	cc.	26		
j.	19	t.	20	dd.	30		

Objective 2

Topographic analysis—The configuration of a surface including its relief and the position of streams, roads, cities, etc.; usually subdivided into relief features, water and drainage features, manmade features, and vegetation

Objective 3

Answers may be in any order:

a. Hypsometric map
b. Digital elevation model (DEM)
c. Topographic map

Objective 4

Any six of the following:

a. As bases for other maps
b. Planning highways
c. Selecting airport sites
d. Selecting industrial sites
e. Planning subdivisions
f. Routing pipelines and power lines
g. Locating boundary lines for cadastral surveys
h. Planning communication facilities
i. Aiding in agricultural research
j. Planning recreation areas
k. Assessing and managing natural resources

Objective 5

Topographic survey—The method of finding positions of natural and manmade features on the surface of the earth as well as determining the configuration of the terrain; a topographic map can then be developed from data obtained through this type of survey

Objective 6

b

Answers to Written Test

Objective 7

a. 3
b. 5
c. 6
d. 2
e. 1
f. 4

Objective 8

Any six of the following:

a. Purpose of survey
b. Map use
c. Map scale
d. Contour interval
e. Size and type of area involved
f. Cost
g. Equipment and time available
h. Experience of survey personnel

Objective 9

b, c

Objective 10

c

Objective 11

a. 2
b. 4
c. 1
d. 5
e. 3

Objective 12

Digital elevation model—Three-dimensional array which provides a digital representation of continuous relief of an area of land. Data collected for this type of automated contouring system are in an array of points. Horizontal positions are x and y coordinates with their elevations represented as z coordinates.

Objective 13

a. Grid method: Elevations are determined by points which conform to a regular square or rectangular grid; a disadvantage of this method is points are only picked up at grid intersections

b. Irregular method: Controlling point method which involves determining the elevations of all high and low points and points where slope changes

Objective 14

Breaklines—Linear topographic features which have uniform slopes, such as streams, lake shores, roads, railroads, ditches, ridge lines; these breaklines become sides of the triangle in the TIN model and elevations are then interpolated along them

Objective 15

a, b, c, e

Answers to Written Test

Objective 16

a. 1/50
b. 1/2

Objective 17

a. 1:24,000[1]
b. about 1 mile
c. 1:100,000
d 1°x2°
e. 1:1,000,000

Objective 18

a, b, f

Objective 19

a. elevations
b. within or without
c. depression
d. overhanging cliff
e. evenly
f. right
g. upgrade, downgrade
h. even
i. Upstream
j. Cannot
k. Heavier

Objective 20

a. short
b. heavy
c. do not give
d. general
e. center

Objective 21

a. 8
b. 2
c. 3
d. 4
e. 5
f. 9
g. 10
h. 7
i. 1
j. 6

Prerequisites:
Unit 1, 2, 3, 4, and 6

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet

☐ 3. **Study** Information Sheet, Objective1 to familiarize yourself with common terms used in topographic mapping.

☐ 4. **Study** Information Sheet, Objectives 2 through 11.

☐ 5. **Study** Information Sheet, Objectives 12 through 15.

☐ 6. **Study** Information Sheet, Objectives 16 through 18, and Student Supplement 1.

☐ 7. **Study** Information Sheet, Objectives 18 through 21.

☐ 8. **Study** Student Supplement 2.

☐ 9. **Study** Student Supplement 3.

☐ 10. **Stop** Ask your instructor to demonstrate how to use a polar planimeter, or view video provided by instructor.

☐ 11. **Do** Assignment Sheet 1, "Use a Polar Planimeter to Determine Acreage."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 11 and 12.

☐ 13. **Study** Student Supplement 4.

☐ 14. **Do** Assignment Sheet 2," Interpolate Contours From a Grid Survey and Prepare Profiles From the Contour Map."

Learning Activities Sheet

☐ 15. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 14 and 15.

☐ 16. **Study** Student Supplements 5 and 6.

☐ 17. **Do** Assignment Sheet 3, "Calculate Grades."

☐ 18. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 19. If the evaluation is not satisfactory, repeat steps 16 through 18.

☐ 19. **Go** To computer and complete Assignment Sheet 4, "Build a TIN and Make Contours."

☐ 20. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 21. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 19 and 20.

☐ 21. **Check** With instructor for any additional assignments to be completed.

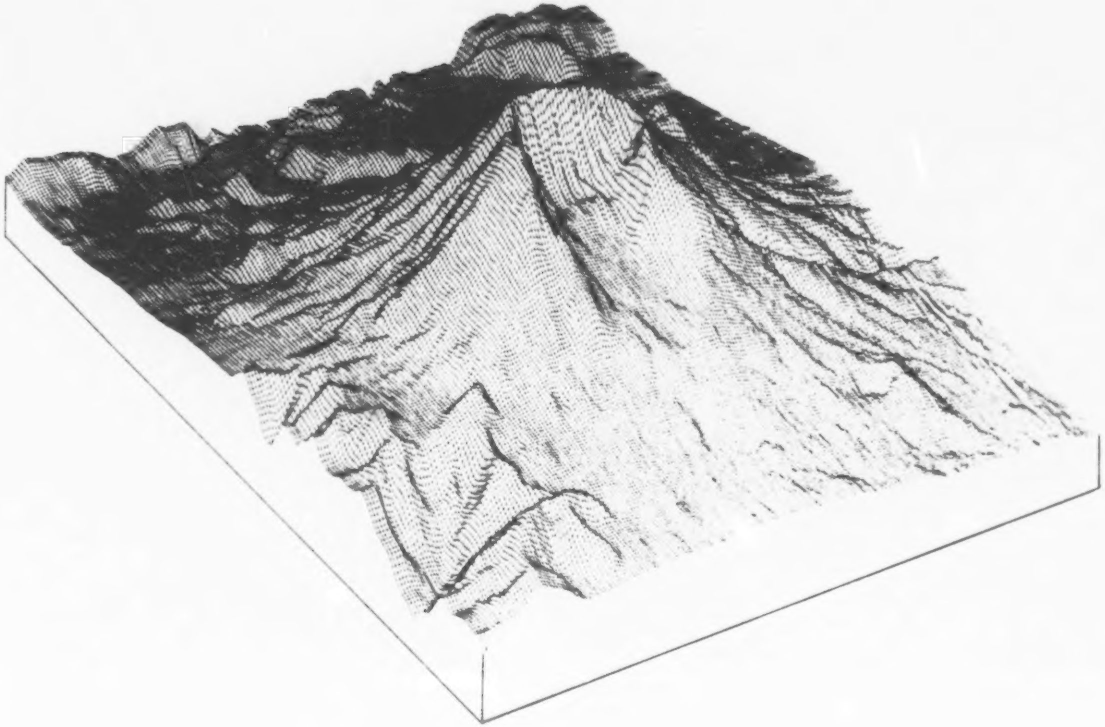
☐ 22. **Do** Additional assignments listed below.

☐ 23. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

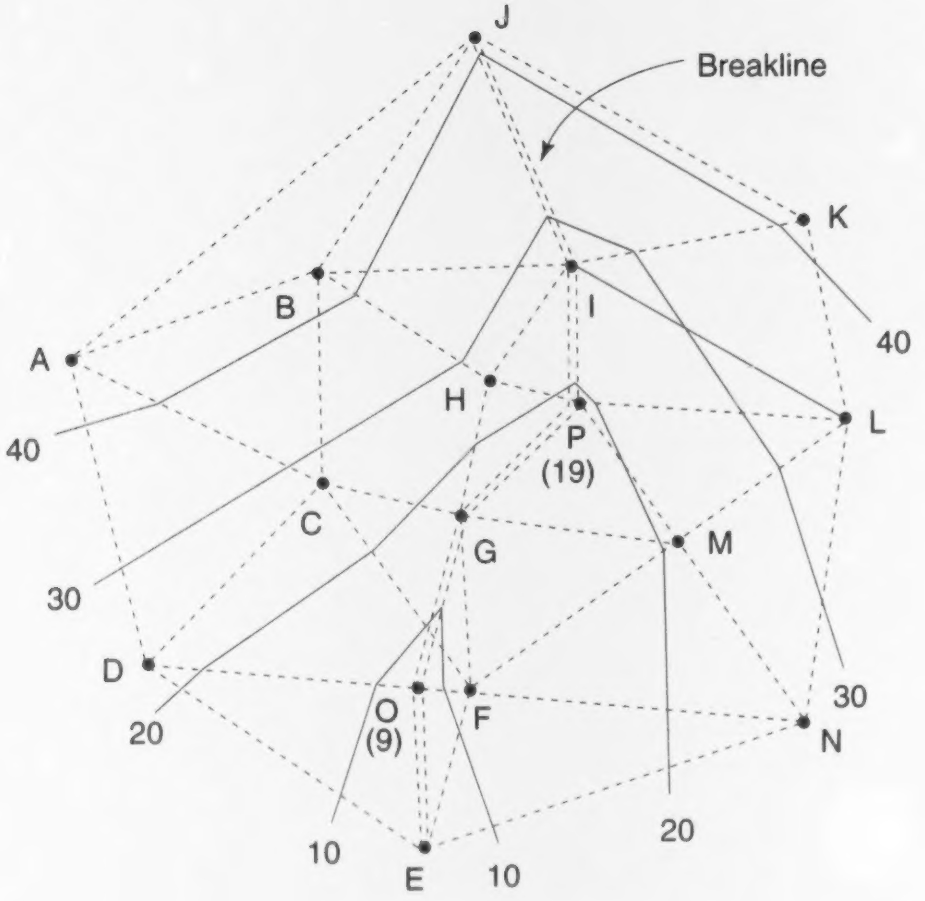
☐ 24. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Digital Elevation Model (DEM)



Triangulated Irregular Network (TIN)


J
Breakline
K
40
B
I
A
L
40
H
P
(19)
C
G
M
30
D
30
O
(9)
F
N
20
20
10
E
10

ELEMENTARY SURVEYING 9/E by Wolf/Brinker, ©1998.
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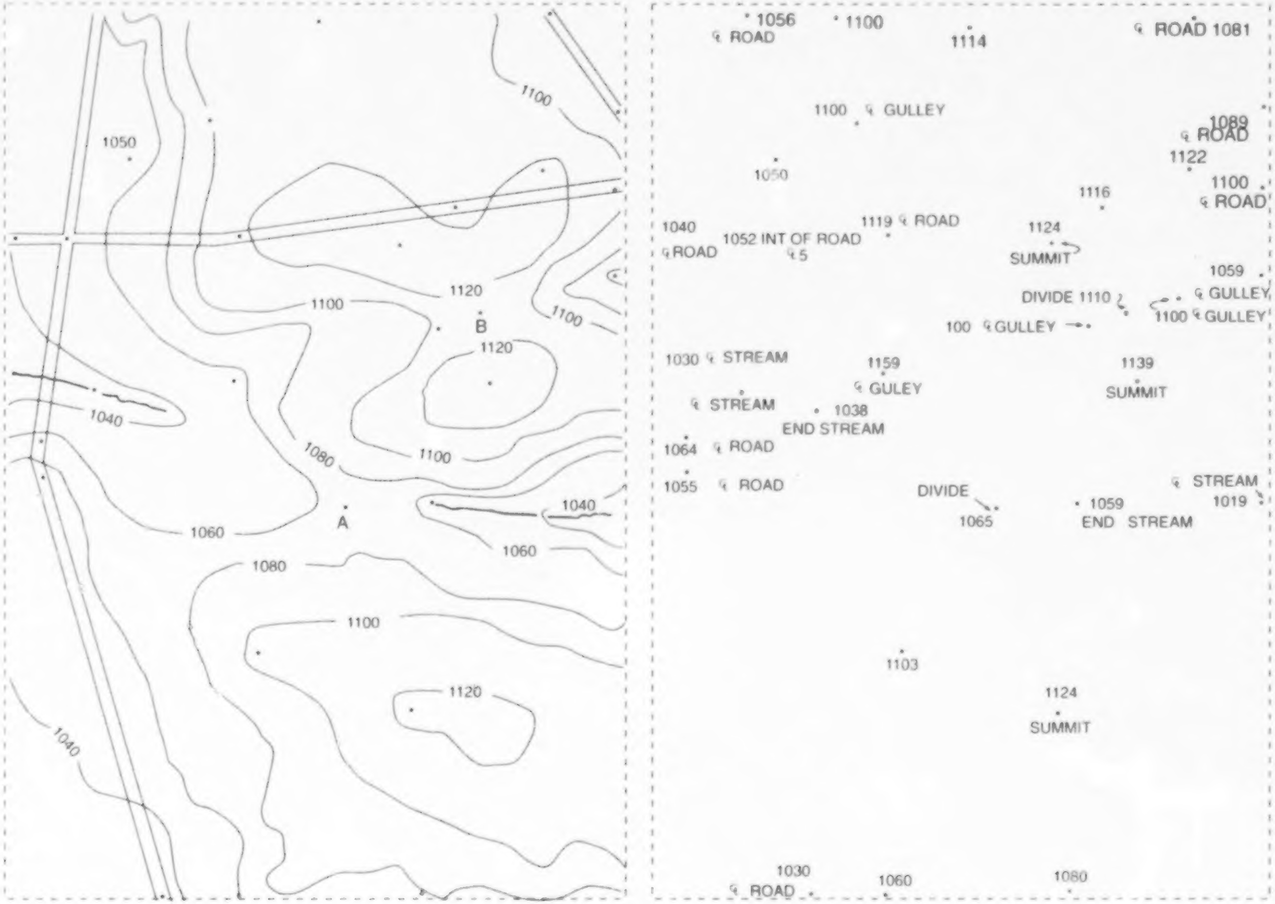
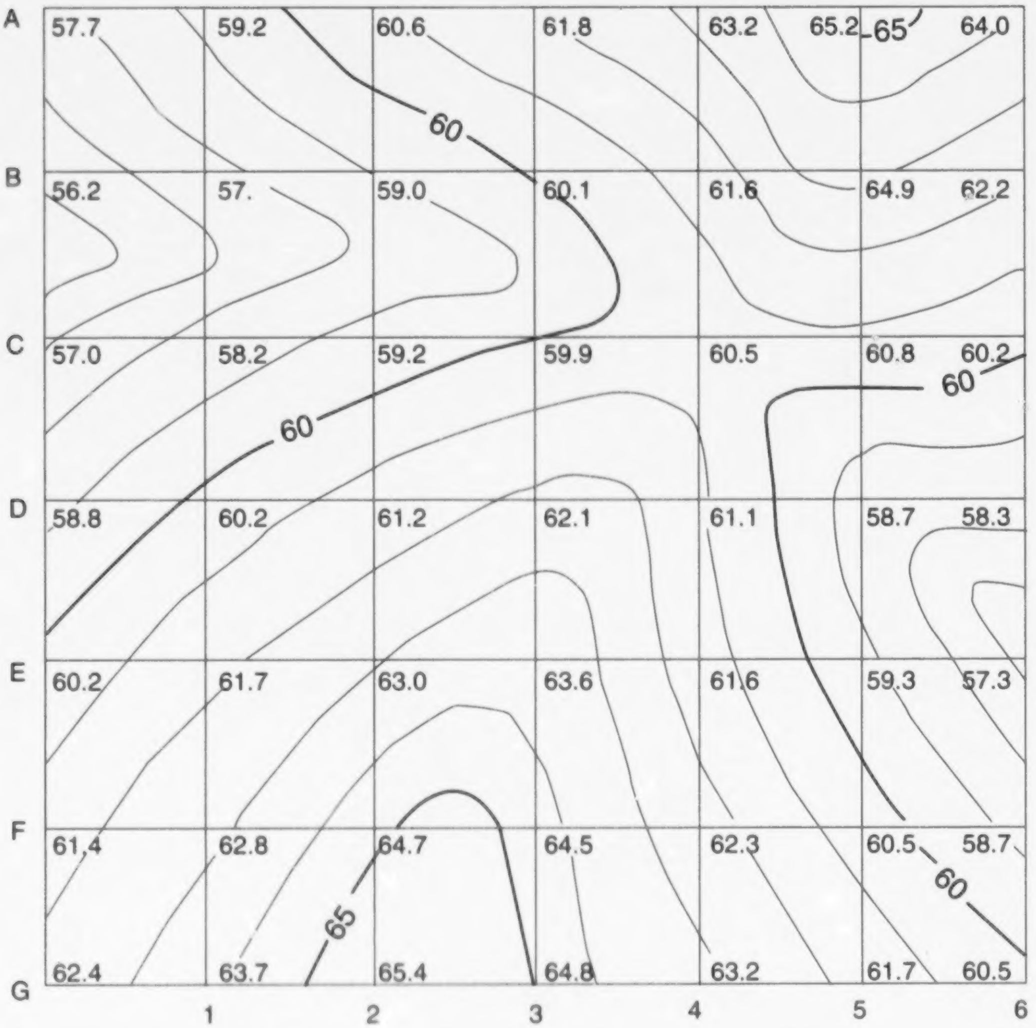
Random Shot Method for Establishing Contours


1100
1050
1120
1100
1100
B
1120
1040
1080
1100
1040
A
1060
1060
1080
1100
1120
1040
1056
℄ ROAD
1100
1114
℄ ROAD 1081
1100 ℄ GULLEY
1089
℄ ROAD
1122
1050
1116
1100
℄ ROAD
1040
℄ ROAD
1052 INT OF ROAD
℄ 5
1119 ℄ ROAD
1124
SUMMIT
1059
℄ GULLEY
DIVIDE 1110
1100 ℄ GULLEY
100 ℄ GULLEY
1030 ℄ STREAM
1159
℄ GULEY
1139
SUMMIT
℄ STREAM
1038
END STREAM
1064 ℄ ROAD
1055 ℄ ROAD
DIVIDE
1065
1059
END STREAM
℄ STREAM
1019
1103
1124
SUMMIT
1030
℄ ROAD
1060
1080

From *Modern Topographic Drawing* by Robert Steele. Reprinted with permission of the Gulf Publishing Company.

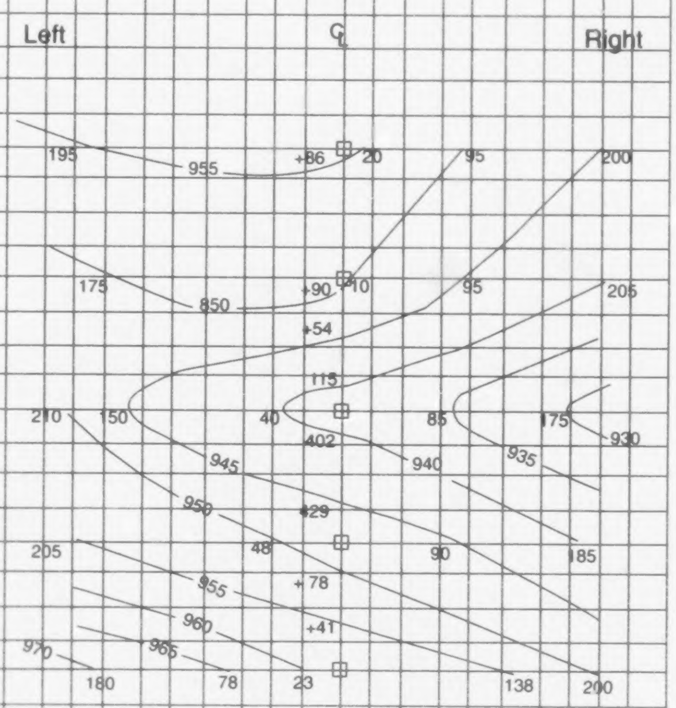
Grid Method for Establishing Contours


A
57.7
59.2
60.6
61.8
63.2
65.2
65
64.0
60
B
56.2
57.
59.0
60.1
61.6
64.9
62.2
C
57.0
58.2
59.2
59.9
60.5
60.8
60.2
60
60
D
58.8
60.2
61.2
62.1
61.1
58.7
58.3
E
60.2
61.7
63.0
63.6
61.6
59.3
57.3
F
61.4
62.8
64.7
64.5
62.3
60.5
58.7
60
65
G
62.4
63.7
65.4
64.8
63.2
61.7
60.5
1
2
3
4
5
6

From *Map Drafting and Related Computations for Plane Surveying: Field Book*. Reprinted with permission of the Vocational Curriculum Development and Research Center, Natchitoches, Louisiana.

Cross Profile Method for Establishing Contours

Station	Elevation
109	956.8
108	950.7
107	938.4
106	948.6
105	958.7


Left
℄
Right
195
955
+86
20
95
200
175
850
+90
10
95
205
+54
115
210
150
40
85
175
930
402
940
935
945
950
+29
205
48
90
185
955
+78
960
+41
970
965
180
78
23
138
200

Leveling Procedure

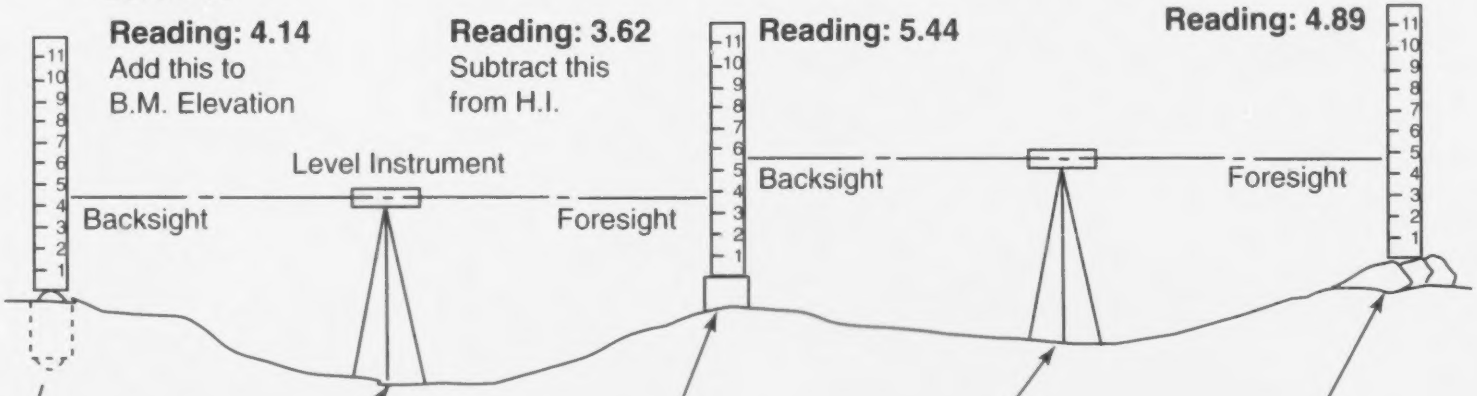
Level Rod

Reading: 4.14
Add this to
B.M. Elevation

Reading: 3.62
Subtract this
from H.I.

Reading: 5.44

Reading: 4.89


Level Instrument
Backsight
Foresight
Backsight
Foresight
1 2 3 4 5 6 7 8 9 10 11

Elevation
1000.00′
USGS BM
Beginning Point

H.I. = 1000.00′
+ 4.14
1004.14′

TP1 = 1004.14′
+ 3.62
1000.52′

H.I. = 1000.52′
+ 5.44
1005.96′

TP2 = 1005.96′
+ 4.89
1001.07′

Unit 8

Municipal Mapping, Plats and Subdivisions

Unit Contents

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  3—Development of a Geologic Map 8–39

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  6—Research the Plats for Local Utilities 8–61

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Set up a visit to your local planning office and look at the plat books.
- Obtain a copy of your local subdivision drafting standards from your planning office or city engineer.
- Invite your city engineer to speak to your class.
- Obtain the legal description for the property your school is on and draft a plat showing the boundary and exact location of the school.
- Take a field trip to a local utility company and visit the drafting department.
- Invite a field engineer from a utility company to speak on how drawings are used in the field.
- Make a list of all utilities in your area that use drafters. Post their addresses.
- Create a display with a set of drawings showing all the utilities in your school.
- Create Internet assignments for students to research software vendors for GIS.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

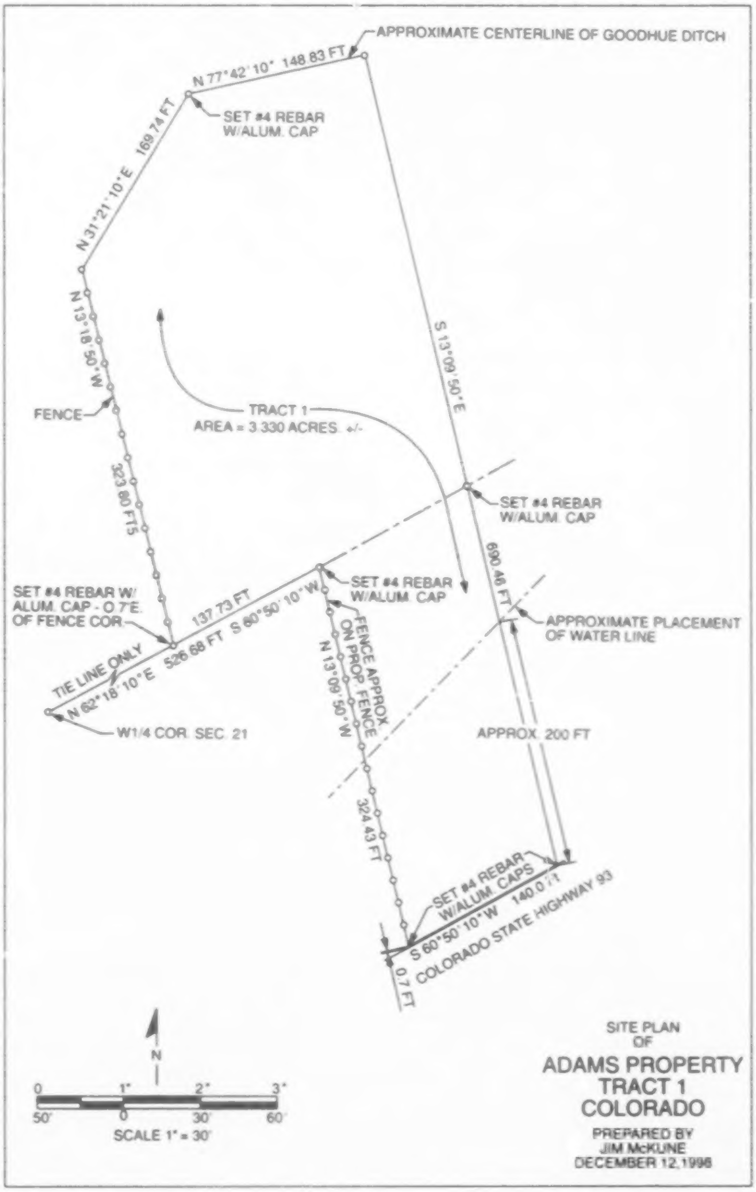
- Colley, Barbara C. *Practical Manual of Land Development*, 3rd ed. New York: McGraw-Hill, Inc., 1998.
- Drafting Standards, Public Service Company of Colorado, Denver Electrical and Gas Distribution Centers.
- Drafting Standards. Public Service Company of Oklahoma, Tulsa.
- Korte, George B., P.E. *GIS Book*, 4th ed. Santa Fe, NM: OnWord Press, 1997.
- Land Use and Land Cover and Associated Maps. USGS. 1-800-USA-MAPS.
- Madsen, David and Terence Shumaker. *Civil Drafting Technology*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1997.
- Plat Standards for Utility Plans. City of Boulder, Colorado.
- State Hydrologic Unit Maps. USGS Books and Open File Report Section. Map Distribution, Box 25286, Federal Center, Denver, CO 80225.
- Subdivision Attachments Standard Requirements. City and County of Boulder, City Planning Department.
- USGS Earth Science Information Center (ESIC). 1-800-USAMAPS.

Answers to Assignment Sheets

Assignment Sheet 1

Lay Out a Boundary Survey From a Legal Description

Sample Final Presentation


APPROXIMATE CENTERLINE OF GOODHUE DITCH
N 77°42'10" 148.83 FT
SET #4 REBAR W/ALUM. CAP
N 31°21'10"E 169.74 FT
N 13°18'50"W
FENCE
323.80 FTS
TRACT 1
AREA = 3.330 ACRES +/-
S 13°09'50"E
SET #4 REBAR W/ALUM. CAP
690.46 FT
APPROXIMATE PLACEMENT OF WATER LINE
SET #4 REBAR W/ ALUM. CAP - 0.7'E. OF FENCE COR.
137.73 FT
SET #4 REBAR W/ALUM. CAP
TIE LINE ONLY
N 62°18'10"E 526.68 FT S 60°50'10"W
FENCE APPROX ON PROP. FENCE
N 13°09'50"W
W1/4 COR. SEC. 21
APPROX. 200 FT
324.43 FT
SET #4 REBAR W/ALUM. CAPS
S 60°50'10"W 140.0 FT
COLORADO STATE HIGHWAY 93
0.7 FT
N
0
1"
2"
3"
50'
0
30'
60'
SCALE 1" = 30'
SITE PLAN
OF
ADAMS PROPERTY
TRACT 1
COLORADO
PREPARED BY
JIM McKUNE
DECEMBER 12,1996

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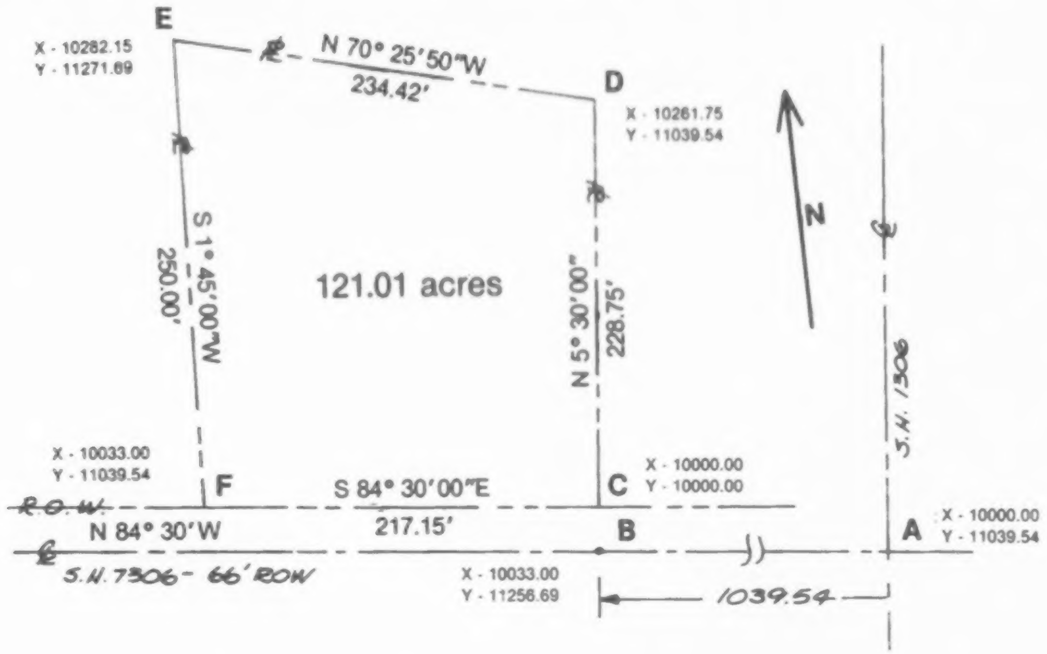
Answers to Assignment Sheets

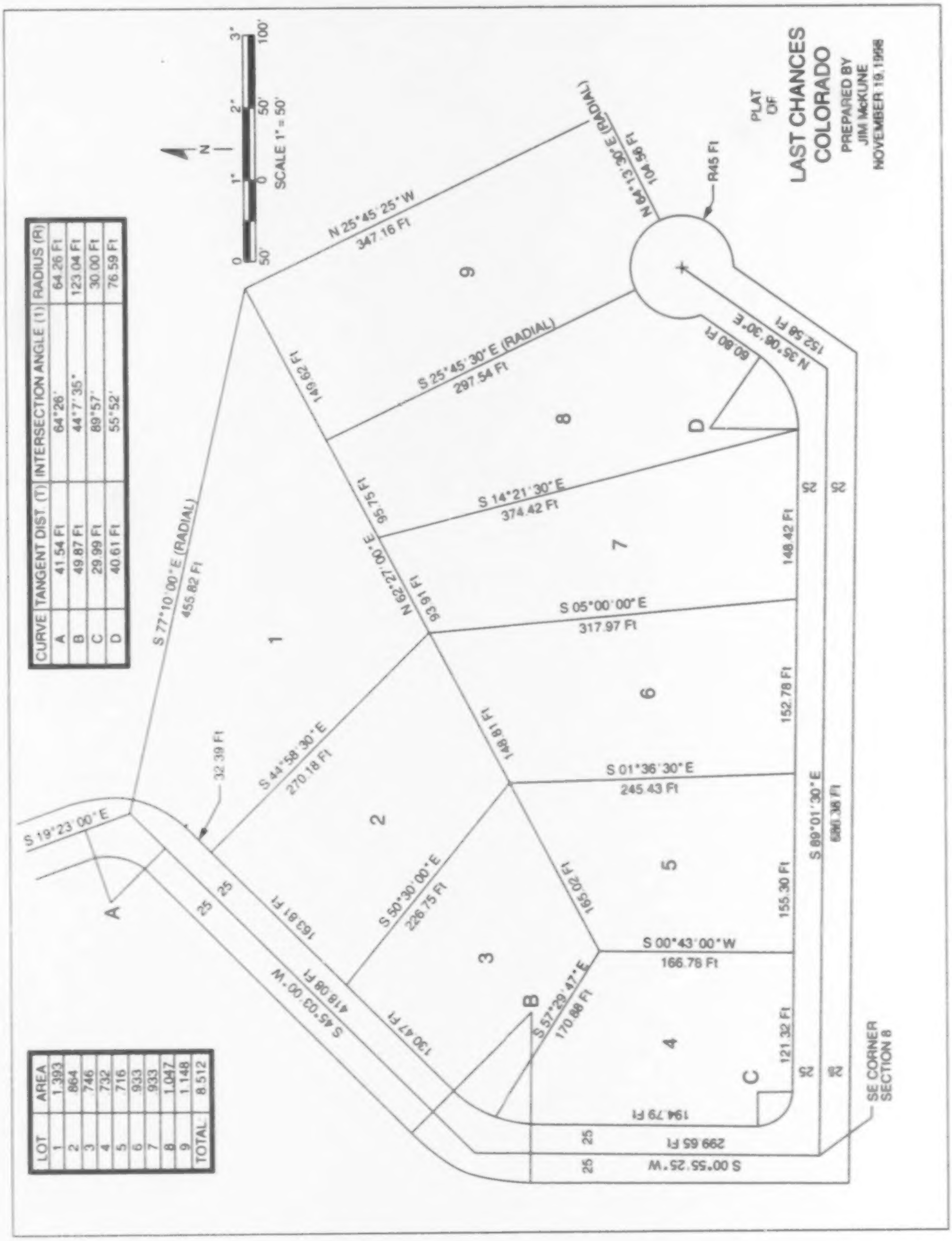
Assignment Sheet 2

Reduce Field Notes and Plot a Simple Boundary Survey


E
X - 10282.15
Y - 11271.69
N 70° 25'50"W
234.42'
D
X - 10261.75
Y - 11039.54
N
S 1° 45'00"W
250.00'
121.01 acres
N 5° 30'00"
228.75'
S.H. 1306
X - 10033.00
Y - 11039.54
F
S 84° 30'00"E
C
X - 10000.00
Y - 10000.00
R.O.W.
N 84° 30'W
217.15'
B
A
X - 10000.00
Y - 11039.54
S.H. 7306 - 66' ROW
X - 10033.00
Y - 11256.69
1039.54

Assignment Sheet 3

Develop From Field Notes the Plat Map for a Nine-Lot Subdivision


PLAT OF
LAST CHANCES
COLORADO
PREPARED BY
JIM McKUNE
NOVEMBER 19, 1998
N
0
1"
2"
3"
50'
0
50'
100'
SCALE 1" = 50'
N 25°45'25"W
347.16 Ft
N 64°13'30"E (RADIAL)
104.56 Ft
R45 Ft
S 77°10'00"E (RADIAL)
455.82 Ft
149.92 Ft
S 25°45'30"E (RADIAL)
297.54 Ft
N 35°06'30"E
152.58 Ft
60.80 Ft
D
95.75 Ft
S 14°21'30"E
374.42 Ft
N 62°27'00"E
93.91 Ft
148.42 Ft
S 05°00'00"E
317.97 Ft
148.81 Ft
152.78 Ft
S 44°58'30"E
270.18 Ft
32.39 Ft
S 19°23'00"E
S 01°36'30"E
245.43 Ft
S 89°01'30"E
686.38 Ft
S 50°30'00"E
226.75 Ft
163.81 Ft
165.02 Ft
155.30 Ft
S 00°43'00"W
166.76 Ft
S 45°03'00"W
418.08 Ft
130.47 Ft
B
S 57°29'47"E
170.68 Ft
121.32 Ft
C
194.79 Ft
299.65 Ft
S 00°55'25"W
25
A
1
2
3
4
5
6
7
8
9
SE CORNER
SECTION 8

CURVE	TANGENT DIST. (T)	INTERSECTION ANGLE (I)	RADIUS (R)
A	41.54 Ft	64°26'	64.26 Ft
B	49.87 Ft	44°7'35"	123.04 Ft
C	29.99 Ft	89°57'	30.00 Ft
D	40.61 Ft	55°52'	76.59 Ft

LOT	AREA
1	1.393
2	.864
3	.746
4	.732
5	.716
6	.933
7	.933
8	1.047
9	1.148
TOTAL	8.512

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Answers to Assignment Sheets

Part 2

	Sq. Ft.	Acres
Lot 1	60674	1.393
Lot 2	37665	0.865
Lot 3	32498	0.746
Lot 4	32013	0.735
Lot 5	31129	0.715
Lot 6	40580	0.932
Lot 7	40585	0.932
Lot 8	45672	1.048
Lot 9	49981	1.147

Total area + Area to ℄ 9.450367 acres

Total area of lots 8.513 acres

Assignment Sheet 4

Redraw to Scale a Complete Final Plat of a 36-Lot Subdivision

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 5

Research the Plat Information for Your Property or a Property in Your Area

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 6

Research the Plats for Local Utilities

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Written Test

Name ____

Date ______________________________ Score__________

Objective 1

Match the terms related to municipal mapping, plats, and subdivisions with their definitions. Terms and definitions continue on the next two pages.

1. Base map
2. Easement
3. Grade plan
4. Hydrology
5. Index map
6. Lateral
7. Monument
8. Overt
9. Peak flow
10. Plan
11. Plot
12. Slope

_____ a. Shows the location of all plats and plat numbers

_____ b. To place survey data upon a map or plat

_____ c. An interest or right in land owned by another that entitles its holder to a specific limited use, such as laying a sewer, crossing over property, or putting up power lines

_____ d. Scientific study of the waters of the earth and the effects of water in the earth's atmosphere, on the earth's surface, and below the earth in the soil and rock

_____ e. A physical structure, such as an iron post, marked stone, or tree in place, which marks the location of a corner point established by a cadastral survey

_____ f. Design or list of steps to accomplish some task; usually drawings made to scale that show necessary information for construction of structures

_____ g. Pipe connecting a utility main to facilities at the sides

_____ h. Contains original ground contours over which contours of highway, subdivision, or other embankment or excavation to be completed are superimposed on and connected with the original ground contours at the edge of construction limits

_____ i. Inside top of a pipe

_____ j. Shows roads, highways, ditches, rivers, lakes, and subdivisions

_____ k. Maximum instantaneous flow

_____ l. The horizontal distance necessary for each foot of vertical height

13. Benchmark
14. Corner
15. Datum line
16. Groundwater
17. Invert
18. Land use classification system
19. Legal description
20. Planning commission
21. Plat, subdivision
22. Plat, use
23. Platting
24. Subdivision plat book
25. Subgrade

_____ m. Either a citizen committee appointed by the chief executive or legislative body to review subdivision plans, or a full- or part-time staff of professional planners hired to carry out continued planning activities, review subdivision plans, conduct studies, etc.

_____ n. In ordinary survey usage, a defined reference line for survey measurement

_____ o. A written statement recognized by law as to the definite location of a tract of land by reference to a survey, recorded map, or adjoining property

_____ p. Material placed below the surface to provide a stable foundation for structures

_____ q. A map of a subdivision of land usually prepared in accordance with state plat statutes or local subdivision regulations or both

_____ r. A relatively permanent material object, natural or artificial, bearing a marked point whose elevation above or below an adopted datum is known

_____ s. Inside bottom of a pipe; the flow line

_____ t. A public record showing the location, size, and name of owners of various recorded plats in the municipality or county

_____ u. A point on the surface of the earth, determined by the surveying process, which defines an extremity on a boundary of public lands

_____ v. Subsurface water that saturates pores or cracks in soil or rocks; stored in and moves through moderately to highly permeable rocks called aquifers

_____ w. The process of preparing a plat or subdivision according to state and local ordinances

_____ x. The component of the new status records, a copy of the master title plat which shows in addition to survey, ownership and restrictive data, leases, licenses, and permits currently effective

_____ y. Coding system of categories and subcategories designed for use on a map to designate land or water use

26. Cadastral survey
27. Compaction
28. Corner description
29. Cul-de-sac
30. Distribution map
31. Flow diagram
32. Grubbing
33. Infiltration rate
34. Municipal mapping
35. Percolate

_____ z. To pass through a porous material

_____ aa. The clearing of roots and stumps from the ground

_____ bb. Creates, marks, defines, retraces, or reestablishes the boundaries and subdivisions of the land

_____ cc. Drawing that shows a system in a symbolic manner as opposed to conventional mapping format

_____ dd. A dead-end street which widens sufficiently at the end to permit an automobile to make a "U" turn

_____ ee. Time it takes for water to seep into the soil, or rate at which groundwater seeps into sewer line

_____ ff. The degree of soil compressibility

_____ gg. Contains one-line configurations of all overhead and underground primary and secondary utility lines

_____ hh. The recordation of public utilities such as gas, electric, water, and sewer lines onto a map for public record

_____ ii. The specific data (both old and new) about a corner monument and its accessories, which include marks, positions, and physical characteristics

Objective 2

Define subdivision planning.

____

____

Objective 3

Select from the following list the official agents who may regulate subdivision planning by placing an "X" next to the correct agents.

_____ a. City council

_____ b. Mayor

_____ c. Chamber of Commerce Executive Director

_____ d. City and county planning commission

_____ e. County commissioners

Written Test

Objective 4

List eight elements to consider when developing a parcel of land.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

Objective 5

Match resource maps and documents used in land development with their descriptions.

1. Street maps
2. Aerial maps
3. Zoning maps
4. Assessor's parcel maps
5. USGS maps
6. Deed
7. Title report
8. Survey maps
9. Spread sheet
10. Parcel map
11. Subdivision map

_____ a. Shows exact legal location and description of plots of land

_____ b. Tax maps that identify land ownership and overall boundary information which is useful in early development stages

_____ c. Legal description of the property

_____ d. Required if more than five parcels are created

_____ e. Shows location of streets in relation to land to be developed

_____ f. Show zoning districts which aids in land use decisions

_____ g. Accurate maps that verify topography and property lines through a field survey

_____ h. Used in the planning stages of a project for planning locations, for presentation to the public or base maps

_____ i. Document prepared by title insurance company which provides the legal description and any claims to the property in the form of easements, taxes, mortgages, mineral or water rights

_____ j. A computer-generated document that is used to chart cost estimates, earth work calculations, etc.

_____ k. Provide large scale data for an area regarding topography, well locations, vegetation, and other natural features

Objective 6

Complete the following statements concerning types of plans by filling in the blanks with the correct words.

a. Elevations and slope of the site are shown on a ____________________.

b. ____________________ shows signalization, signage, lighting, striping, and guardrails.

c. A final set of construction plans is called ____________________.

d. This ____________________ shows how one site relates to the larger plan in the community.

Objective 7

List five types of utilities.

a. ____

b. ____

c. ____

d. ____

e. ____

Objective 8

List four agencies that develop and maintain municipal maps.

a. ____

b. ____

c. ____

d. ____

Objective 9

List five users of municipal maps.

a. ____

b. ____

c. ____

d. ____

e. ____

Written Test

Objective 10

Select from the following list types of drawings used in municipal mapping by placing an "X" in the appropriate blanks.

_____ a. Obstruction maps

_____ b. Geological maps

_____ c. Aeronautical maps

_____ d. Plat maps

_____ e. Index maps

_____ f. Distribution maps

_____ g. Flow diagrams

_____ h. Profile

_____ i. Plan

_____ j. Cross sections

_____ k. Base maps

_____ l. Bill of materials (quantity sheets)

Objective 11

List two methods of presenting utilities on maps.

a. ______________________________

b. ______________________________

Objective 12

List five types of support information needed to develop utility drawings for a specific area.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

Objective 13

Match colors with the utilities they represent by placing the corresponding numbers in the appropriate blanks.

1. Red or blue
2. Yellow
3. Green/Orange
4. Green or orange
5. Blue and yellow dashed
6. Purple or red
7. Yellow and helio dashed
8. Helio
9. Orange

_____ a. Gas

_____ b. Water

_____ c. Sanitary sewer and storm sewer

_____ d. Telephone

_____ e. Electric

_____ f. Steam

_____ g. Petroleum pipelines

_____ h. Radar and missile cables

_____ i. F.O.

Objective 14

Complete the following statements concerning utility easements by circling the correct words.

a. Utility easements are usually shown on the (**plan and profile, subdivision plat**) to indicate the location of any and all utilities.

b. Generally each utility will be located in a standard location with reference to the (**front, back, side**) property line(s).

Objective 15

List five types of information included on utility drawings.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

Written Test

Objective 16

Match types of valves and valve housings with their definitions.

1. Ball valve
2. Check valve
3. Gate valve
4. Globe valve
5. Plug valve
6. Pressure regulator valve
7. Pressure safety valve
8. Valve box
9. Valve vault

_____ a. Used to protect equipment and workers from sudden and dangerous excess pressures

_____ b. Used for flow regulation, throttling, and frequent operation

_____ c. Used for quick start-stop operations; has a ball to stop flow through valve

_____ d. Used to automatically maintain accurate, constant, and uniform flow in a line

_____ e. An underground structure designed to house a valve 8" and larger or a series of valves

_____ f. Used for infrequent start-stop operations; has a disk to stop flow through valve

_____ g. Used to prevent backflow; available as swing or lift for different applications

_____ h. A small structure designed to house a valve up to and including 6"

_____ i. Used for quick start-stop operations; has a slotted core or plug that stops flow when turned 90°

Objective 17

Match types of sewers and sewer lines with their descriptions. Descriptions continue on next page.

1. Branches
2. Cleanouts
3. Combined sewer
4. Funnel
5. Laterals
6. Process sewer
7. Sanitary sewer
8. Sewer mains
9. Storm sewer

_____ a. Collects rain wash and fire water

_____ b. Collects water from drains of equipment, drips from pumps, and other dirty drains

_____ c. Collects both storm and process sewers utilizing only one piping system

_____ d. Carries human wastes

_____ e. Liquid collection point that usually projects about 2" above the finished grade

_____ f. Lines (4" minimum) that collect from various drain funnels or catch basins and tie to sublaterals

_____ g. Sewer lines collecting from two or more sublaterals and discharging to mains through a sealed manhole

_____ h. Lines that collect flow from two or more laterals and are usually located in roadway easements; are sealed at regular intervals with manholes to prevent the spread of fire or gas backup

_____ i. Openings located at the ends of branches and long line runs which allow the sewer to be cleaned by removing a plug and inserting a long flexible steel bar

Objective 18

Select true statements concerning water lines by placing an "X" in the blanks next to the true statements.

_____ a. Centers of water pipelines are aligned the same as the overt of the pipe.

_____ b. Water lines are a closed system.

_____ c. Water lines may have standard locations dependent on local regulations.

_____ d. Water company will dictate the size, location, and types of pipes to be used.

_____ e. Water lines are laid out in a grid-like manner.

Written Test

Objective 19

Match types of gas piping and devices with their definitions.

1. Casing
2. Casing, insulated
3. Control line
4. Cover
5. Main ending
6. Manhole
7. Marker, pipeline
8. Meter
9. Meter riser
10. Nipple
11. Pole line
12. Regulator station
13. Riser
14. Service, low pressure
15. Service regulator

_____ a. An opening at the top of a valve vault making housed valves accessible at all times

_____ b. Distance between top of pipe and street surface

_____ c. Equipment designed to reduce and control gas pressure manually, automatically, or by remote control

_____ d. A small pipe, usually $^{3}/_{4}''$ or $1^{1}/_{4}''$, used in connection with a regulator station to control pressure rather than to transport gas

_____ e. Same as casing, but carrier is insulated from pipe with insulated spacers and bushings

_____ f. Gas piping installed in a vertical position, usually exposed and fastened to building walls, poles, or other rigid structures

_____ g. A wooden post 8' in length with metal warning signs on two sides in line with the pipeline installed directly over the main where measurements from a permanent object or source are not available

_____ h. That portion of pipe used for transporting low pressure gas from the main to the meter

_____ i. Pipe sleeve generally used for railroad, highway, ditch, and bridge crossings to enclose the main in a protective casing

_____ j. Power or telephone line usually set 1 foot on road side of property line

_____ k. A short piece of pipe

_____ l. Distance to end of main from a stationary point such as property line, pole line, etc.

_____ m. A portion of piping vertical to the ground used for the installation of an outside meter

_____ n. A device designed to reduce gas pressure and maintain constant pressure for customer's use; located between the service terminal valve and the gas meter

_____ o. A device for measuring customer gas usage in cubic feet

Objective 20 Define a geologic report.

____

____

____

Objective 21 Select true statements concerning the soils report by placing an "X" in the blanks next to the true statements.

_____ a. Core samples are taken to show underlying strata.

_____ b. The soils report includes information on the compaction rate of the top soil.

_____ c. The soil report will provide useful information for the design of the structure.

Objective 22 Define the purpose of a site analysis.

____

____

____

Objective 23 List eight items to consider when conducting a site analysis.

a. ______________________________
b. ______________________________
c. ______________________________
d. ______________________________
e. ______________________________
f. ______________________________
g. ______________________________

Objective 24 List six types of report and permits required for a development site.

a. ______________________________
b. ______________________________
c. ______________________________
d. ______________________________
e. ______________________________
f. ______________________________

Written Test

Objective 25

Arrange in order the following steps for planning a subdivision by placing the correct sequence numbers (1-5) in the appropriate blanks.

_____ a. A tentative plan is developed to show outline of property, proposed title of the subdivision, proposed layout, topographic features, existing easements, legal description, as well as other information.

_____ b. The planning office and city engineer are consulted for governing rules and regulations of local planning agencies.

_____ c. After the tentative plan is approved and all changes are made, a final subdivision plat is drawn up, and then has to receive final approval from the appropriate governing agency.

_____ d. A small scale location map is developed to show the relation of the subdivision to the surrounding properties.

_____ e. The tentative map is presented for review to the clerk of the advisory agency such as the planning commission.

Objective 26

Complete the following statements concerning the final recordation of a subdivision plat by correctly filling in the blanks.

a. The final plat is considered a legal working document and will be on file at the ______________________________.

b. It is drawn at a scale of ______________________________.

c. Items required on a final plat include the following: (list six)

- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________

d. The title sheet will include: (list five)

- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________

298

Objective 27

Select from the following list the individuals who certify and approve the final plat map by placing an "X" on the blanks next to their names.

_____ a. Financial institution—mortgage release

_____ b. Chief drafter

_____ c. Private engineer or surveyor

_____ d. City attorney

_____ e. Public engineer or surveyor

_____ f. City agent

_____ g. State treasurer

_____ h. Owner

_____ i. Clerk and recorder

Objective 28

Complete the following statements concerning legal descriptions by circling the correct words.

a. Are (**written, oral**) descriptions describing the relationship of a parcel of land to the surrounding surveys

b. A complete description will begin with the (**small, broad overall**) division and progress to the (**small, broad overall**) details.

Objective 29

Define Geographic Information System (GIS).

____

____

____

Objective 30

List six applications for GIS.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

Written Test

Objective 31

Select true statements about the advantages of GIS by placing an "X" in the blanks next to the true statements.

_____ a. Map data is less secure and more globally accessible.

_____ b. Map data is integrated throughout the organization.

_____ c. Map revisions are very difficult due to the multiple sets of map data.

_____ d. Redundancy of multiple map sets is eliminated.

Objective 32

Complete the following statements concerning what makes GIS work by correctly filling in the blanks.

a. A system like ____________________ or ____________________ can be used.

b. Any variable that can be located ____________________ can be fed into a GIS.

c. A GIS can convert existing ____________________ information into a recognizable map form.

Objective 33

Select true statements about GIS and data integration by placing an "X" in the blanks next to the true statements.

_____ a. GIS can restructure data into different formats.

_____ b. GIS can be used to depict two and three-dimensional characteristics of the earth's surface, subsurface, and atmosphere from information points.

_____ c. GIS uses digital information to create links between mapping agencies.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a.	5	j.	1	s.	17	bb.	26
b.	11	k.	9	t.	24	cc.	31
c.	2	l.	12	u.	14	dd.	29
d.	4	m.	20	v.	16	ee.	33
e.	7	n.	15	w.	23	ff.	27
f.	10	o.	19	x.	22	gg.	30
g.	6	p.	25	y.	18	hh.	34
h.	3	q.	21	z.	35	ii.	28
i.	8	r.	13	aa.	32		

Objective 2

The process of dividing urban land into orderly, accurately surveyed parcels

Objective 3

a, d, e

Objective 4

Answers may include any eight of the following:

a. Resources
b. Public agencies
c. Site analysis
d. Preliminary design
e. Preliminary engineering
f. Geologic report
g. Soils report
h. Earthwork: grading and quantities
i. Roadways and parking lots
j. Sanitary sewers
k. Storm drainage
l. Water supply lines
m. Regulations for building heights, parking facilities, and right-of-way setback lines
n. Utility regulations

Objective 5

a.	10	d.	11	g.	8	j.	9
b.	4	e.	1	h.	2	k.	5
c.	6	f.	3	i.	7		

Objective 6

a. grading plan
b. traffic plan
c. as-built plans
d. master plan

Answers to Written Test

Objective 7

Any five of the following:

a. Gas
b. Electric
c. Water
d. Sewer
e. Telephone
f. Cable for television
g. Drainage

Objective 8

Any four of the following:

a. Public service companies
b. Rural power companies
c. Department of public works
d. Department of waste management
e. Telephone company
f. Water department

Objective 9

Any five of the following:

a. Architects
b. Land developers
c. City planners
d. Telephone company
e. Builders
f. Zoning department
g. Individuals
h. Engineers
i. Surveyors

Objective 10

a, d, e, f, g, h, i, k, l

Objective 11

Any two of the following:

a. Separate maps for each utility
b. Base map with overlays to show the location for each utility
c. Composite maps
d. CAD—Each utility can be stored on a separate layer in the computer
e. Graphic information software (GIS)

Answers to Written Test

Objective 12

Any five of the following:

a. Adjacent plats
b. Miscellaneous information on subs, ordinances, and deed pertaining to plat to be drawn
c. Aerial photos
d. Railroad maps
e. Highway maps
f. USGS maps
g. Easement file
h. Transmission pipeline plats
i. Obstruction maps
j. Electric transmission right-of-way

Objective 13

a. 2
b. 1
c. 3
d. 4
e. 6
f. 5
g. 8
h. 7
i. 9

Objective 14

a. subdivision plat
b. front

Objective 15

Any five of the following:

a. Easement dimensions
b. Symbols and labels
c. Bill of materials
d. Schematic symbols for fittings, valves, sewer lines, water lines, and taps
e. Manhole locations
f. Distance of gas main, sewer line, or water tap from property line
g. Sizes and types of valves and lines
h. Locations of obstructions
i. Existing and proposed utility lines
j. Underground cables
k. Street lighting symbols (depending on type of drawing)

Objective 16

a. 7
b. 4
c. 1
d. 6
e. 9
f. 3
g. 2
h. 8
i. 5

Objective 17

a. 9
b. 6
c. 3
d. 7
e. 4
f. 1
g. 5
h. 8
i. 2

Answers to Written Test

Objective 18

b, c, d, e

Objective 19

a.	6	e.	2	i.	1	m.	9
b.	4	f.	13	j.	11	n.	15
c.	12	g.	7	k.	10	o.	8
d.	3	h.	14	l.	5		

Objective 20

This report is constructed by a geologist. The geologic history of the site and subsurface studies will be used to determine suitability for development.

Objective 21

a, c

Objective 22

To provide an engineered feasibility study, cost estimates, and preliminary design for land development that includes purpose and limitations, location, and description

Objective 23

Any eight of the following:

a. Description of location
b. Description of the environment
c. Description of the site
d. Existing zoning
e. Required zoning
f. Streets
g. Sanitary district
h. Flood control district
i. Water supply district
j. Utilities: electric, gas, telephone, cable tv
k. Grading

Objective 24

Any six of the following:

a. Air pollution
b. Traffic
c. Noise pollution
d. Water
e. Geological
f. Soils
g. Archeological
h. Historical
i. School impacts
j. Flood control district
k. Environmental impact report (EIR)

Objective 25

a. 3
b. 1
c. 5
d. 2
e. 4

Objective 26

a. county courthouse
b. 1″ = 100′ or larger
c. Any six of the following:
  - Legal description of the property
  - Property lines, dimensions, and bearings
  - Direction of north
  - Proposed setback from all property lines
  - Utility and drainage easements
  - Total acreage
  - Drawing scale
  - Necessary signatures of certification

d. Any five of the following:

  - Certification signatures
  - Caption type description
  - Basis of bearing
  - Monument note
  - Benchmark (if required)
  - Legend (if required)
  - Omission of certain signature (if applicable)
  - Index map of subsequent sheets (if many)
  - North arrow and scale
  - Soil test report (if required)
  - Any special notes

Objective 27

a, c, e, f, h, l

Objective 28

a. written
b. broad overall, small

Objective 29

GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information; for example, data identified according to their locations.

Objective 30

Any six of the following:

a. Scientific investigations
b. Resource management
c. Development planning
d. Tax mapping
e. Planning and land use
f. Voter and school districting
g. Emergency response
h. Public utility management

Objective 31

b, d

Answers to Written Test

Objective 32	a. zip codes, highway mile markers b. spatially c. digital
Objective 33	a, b

Unit 8

Municipal Mapping, Plats and Subdivisions

Prerequisites:
Units 1 through 7

Learning Activities Sheet

Student Name ________________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 and 2 to familiarize yourself with common terms used in municipal mapping, plats, and subdivisions.

☐ 4. **Study** Information Sheet, Objectives 3 through 9.

☐ 5. **Study** Information Sheet, Objectives 10 through 19.

☐ 6. **Study** Information Sheet, Objectives 20 through 24.

☐ 7. **Study** Information Sheet, Objective 25 and Student Supplement 1.

☐ 8. **Study** Information Sheet, Objectives 26 and 27, and Student Supplements 2 and 3.

☐ 9. **Study** Information Sheet, Objective 28 and Student Supplement 4.

☐ 10. **Study** Information Sheet, Objectives 29 through 33.

☐ 11. **Do** Assignment Sheet 1, "Lay Out a Boundary Survey From a Legal Description."

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 11 and 12.

Learning Activities Sheet

☐ 13. **Do** Assignment Sheet 2, "Reduce Field Notes and Plot a Simple Boundary Survey."

☐ 14. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 13 and 14.

☐ 15. **Do** Assignment Sheet 3, "Develop From Field Notes the Plat Map for a Nine-Lot Subdivision."

☐ 16. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 17. If the evaluation is not satisfactory, repeat steps 15 and 16.

☐ 17. **Go** To computer and complete Assignment Sheet 4, "Redraw to Scale a Complete Final Plat of a 36-Lot Subdivision."

☐ 18. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 19. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 17 and 18.

☐ 19. **Do** Assignment Sheet 5, "Research the Plat Information for Your Property or a Property in Your Area."

☐ 20. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 21. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 19 and 20.

☐ 21. **Do** Assignment Sheet 6, "Research the Plats for Local Utilities."

☐ 22. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 23. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 21 and 22.

☐ 23. **Check** With instructor for any additional assignments to be completed.

☐ 24. **Do** Additional assignments listed below.

____

____

____

☐ 25. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 26. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

*Permission to duplicate this form is granted.

Types of Land Descriptions Used in a Legal Description

Public Land Sectional Description

All that part of the Northeast Quarter of the Northeast Quarter of Section 12, Township 5 North, Range 2 East of the Fifth Principal Meridian, Clarion Township, Walker County, and State of Missouri, described as follows:

Commencing at the Northeast Corner of said Section 12;
Thence on an assumed bearing of South 89°58′40″ West on and along the north line of Section 12 a distance of 825.00 feet to the point of beginning;
Thence South 0°02′20″ West a distance of 721.78 feet;
Thence South 89°58′40″ West a distance of 320.22 feet;
Thence North 31°18′20″ West a distance of 844.57 feet to the said north line of Section 12;
Thence North 89°58′40″ East a distance of 759.55 feet on and along the said north line of Section 12 to the point of beginning.

ALSO known as Lot 5, Block 4, Oak Hills Subdivision, Walker County, Missouri.

Lot and Block Description

Metes and Bounds Description

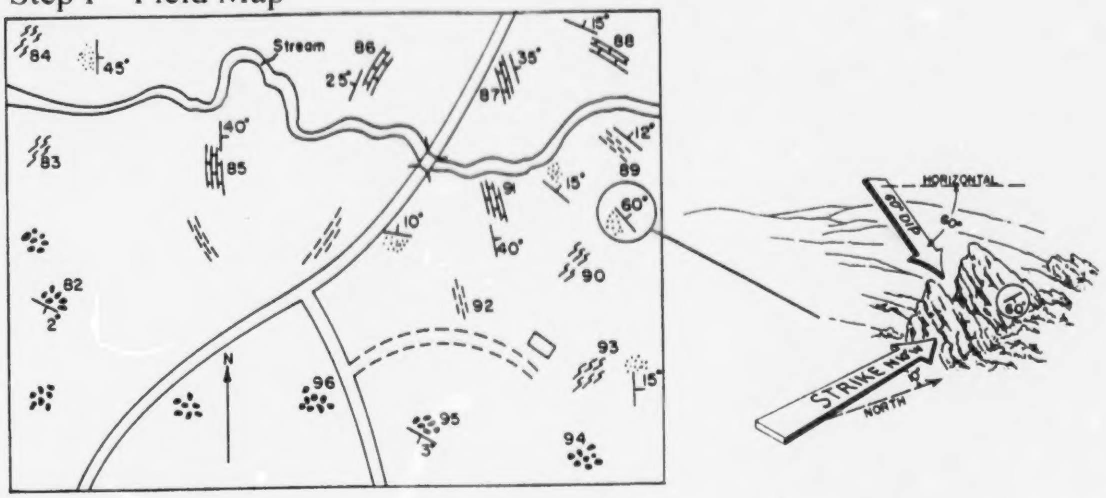
Geologic Time Chart

GEOLOGIC TIME

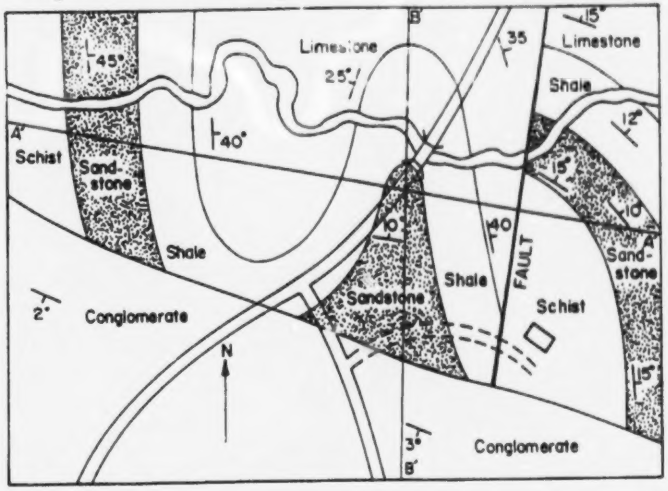
EON	ERA	PERIODS AND SYSTEMS	EPOCHS AND SERIES	BEGINNING OF INTERVAL*	BIOLOGICAL FORMS
Phanerozoic	Cenozoic	Quatternary	Holocene	0.01	
			Plesitocene	1.6	Earliest humans
		Tertiary	Pliocene	5	
			Miocene	24	Earliest humanoids
			Oligocene	37	
			Eocene	58	Earliest grasses
			Palocene	65	Earliest large mammals
		Cretaceous-Tertiary (65 million years ago): extinction of dinosaurs			
	Mesozoic	Cretaceous	Upper	98	
			Lower	144	Earliest flowring plants; dinosaurs in ascendance
		Jurassic		208	Earliest birds & mammals
		Triassic		245	Age of dinosaurs begins
	Paleozoic	Permian		286	
		Carboiferous			
		Pennsylvanian		320	Earliest reptiles
		Mississippian		360	Earliest winged insects
		Devonian		408	Earliest vascular plants (as ferns & mosses)) & amphibians
		Silurian		438	Earliest land plants & insects
		Ordovician		505	Earliest corals
		Cambrian		570	Earliest fish
Proterozoic	Precambrian			2500	Earliest colonial algae & soft-bodied invertibrates
Archean				4000	Life appears: earliest algae & primitive bacteria

Development Of A Geologic Map

Step I—Field Map


Stream
84
45°
86
25°
88
15°
87
35°
83
40°
85
12°
89
91
15°
60°
10°
40°
90
82
2
92
93
96
15°
95
3°
N
94
HORIZONTAL
60° DIP
60°
STRIKE N-W
NORTH

Step II—Final Map of Geologic Outcrops


B'
15°
35
Limestone
Limestone
45°
25°
Shale
12°
A'
40°
Schist
Sand-stone
15°
10°
40
10
A
Shale
Shale
FAULT
Sand-stone
Sandstone
Schist
2°
Conglomerate
N
15°
3°
B
Conglomerate

Unit 9 Transportation Mapping

Unit Contents

Teacher Page

Teacher Components

Suggested Activities 9–3

Answers to Assignment Sheets 9–7

Written Test 9–15

Answers to Written Test 9–25

Learning Activities Sheet 9–29

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2—Field Notes for a Simple Curve 9–33
3—Superelevations of a Roadway 9–35
4—Horizontal Curve 9–37
5—Vertical Curve 9–39
6—Example of a Plan and Profile 9–41
7—Example of Cross Sections 9–43
8—Field Notes for Cross Sections 9–45
9—Areas of Cross Sections 9–47
10—Typical Title Sheet 9–49
11—Example of a Highway Detail (Traffic Signal Plan) 9–51
12—Typical Plan and Profile 9–53

Student Page

Student Components

Objective Sheet 9–3

Information Sheet 9–5

Student Supplements

1—Plotting a Traverse with Angles and Coordinates 9–29
2—Field Notes for a Simple Curve 9–31
3—Superelevations of a Roadway 9–33
4—Horizontal Curve 9–35
5—Vertical Curve 9–37
6—Example of a Plan and Profile 9–39
7—Example of Cross Sections 9–41
8—Areas of Cross Sections 9–43
9—Typical Title Sheet 9–45
10—Example of a Highway Detail (Traffic Signal Plan) 9–47
11—Typical Plan and Profile 9–49

Unit Contents

Assignment Sheets

1—Lay Out Open Traverses Using Several Methods 9–51
2—Lay Out a Survey Alignment for a Road Using Bearings and Coordinates 9–57
3—Calculate the Bearing, Slope, % Grade, True Length, and Azimuth of the ℄ of a Highway 9–59
4—Develop a Plan and Profile and Cross Sections, and Determine Cut and Fill For a Road Alignment 9–61

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Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Write your state highway department and request a set of drafting standards.
- Make a visit to an on-site project and observe cut and fill excavation.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- *A Policy on Geometric Design of Highways and Streets*. American Association of State Highway and Transportation Officials, 1994.

  444 N. Capitol Street NW, Suite 248
  Washington D.C. 20402
  (202) 624-5800
  ISBN:1-56051-068-4

- *Drafting Manual*. Colorado State Department of Highways, Denver, CO.
- Madsen, David and Terence Shumaker. *Civil Drafting Technology*. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1997.
- *Manual of Uniform Traffic Control Devices*. U.S. Government Printing Office, Washington, D.C.
- *Map Drafting and Related Computations for Plane Surveying: Field Book*. Natchitoches, LA: Vocational Curriculum Development and Research Center.

Suggested Activities

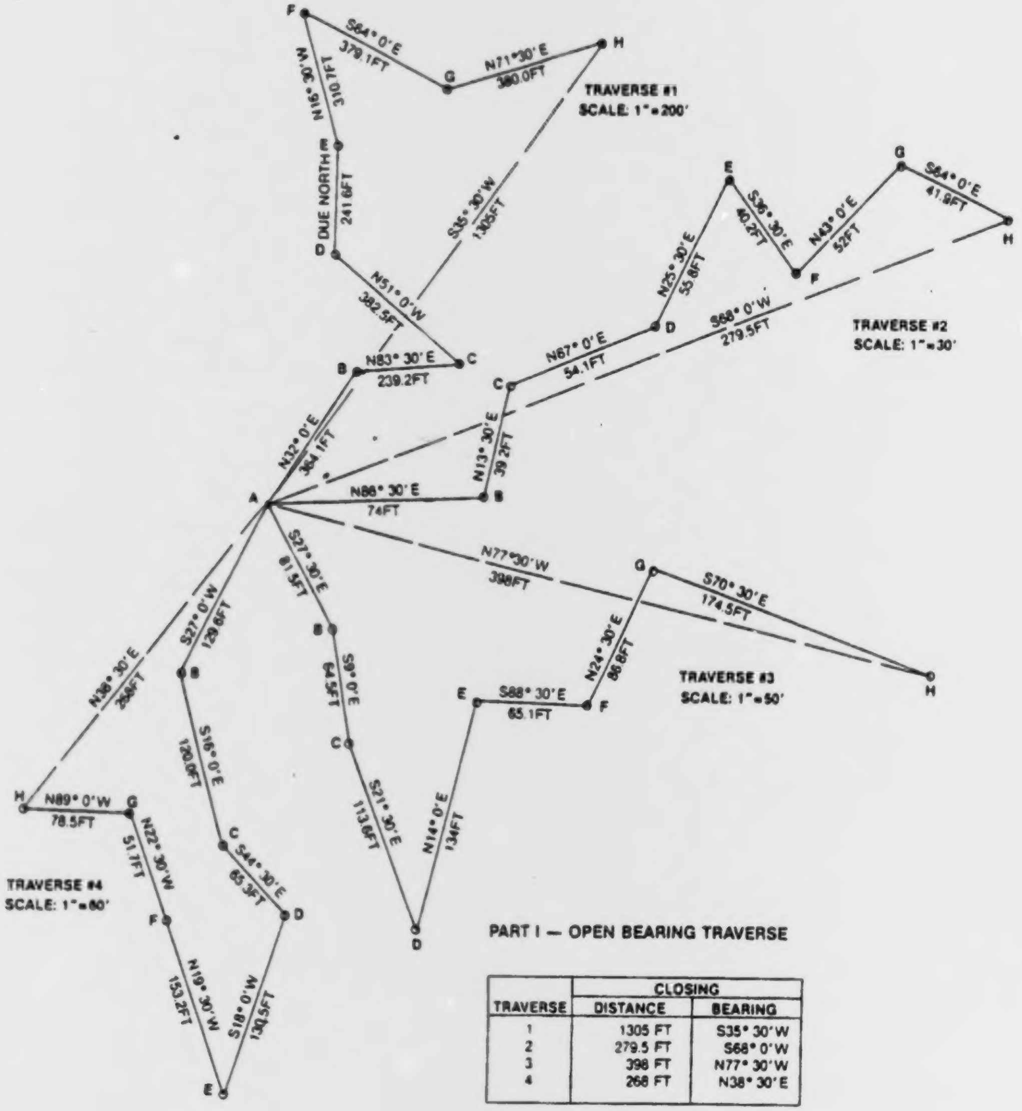
- McCormac, Jack C. *Surveying Fundamentals,* 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc, 1995.
- *Roadside Design Guide.* American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C.,1996. ISBN: 1-56051-031-5.
- Standard Highway Signs, Order No. 950-044-00000-4. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.
- *Surveying Manual.* Colorado State Department of Highways, Denver, CO.
- Wattles, Gurdon. *Survey Drafting,* 2nd ed. Orange, CA: Gurdon H. Wattles Publications, 1981.
- Wirshing, Roy H. and James R. Wirshing. *Civil Engineering Drafting.* New York: Glencoe/McGraw-Hill Inc., 1983, Imprint 1993.

Answers to Assignment Sheets

Assignment Sheet 1

Lay Out Open Traverses Using Several Methods

Part 1: Open Bearing Traverses


F
S64° 0'E
379.1FT
G
N71°30'E
380.0FT
H
TRAVERSE #1
SCALE: 1"=200'
N16°30'W
310.1FT
E
DUE NORTH
241.6FT
D
S35°30'W
1305FT
N51°0'W
382.5FT
C
B
N83° 30'E
239.2FT
N32°0'E
364.1FT
A
E
S36°30'E
40.2FT
N43°0'E
52FT
G
S64°0'E
41.9FT
H
F
N25°30'E
55.8FT
D
S68°0'W
279.5FT
TRAVERSE #2
SCALE: 1"=30'
N67°0'E
54.1FT
C
N13°30'E
39.2FT
B
N86°30'E
74FT
S27°30'E
81.5FT
N77°30'W
398FT
G
S70°30'E
174.5FT
H
B
S9°0'E
64.5FT
N24°30'E
88.8FT
TRAVERSE #3
SCALE: 1"=50'
E
S88°30'E
65.1FT
F
C
S21°30'E
113.6FT
N14°0'E
134FT
D
N38°30'E
268FT
S27°0'W
129.6FT
B
H
N89°0'W
78.5FT
G
S16°0'E
120.0FT
N22°30'W
51.7FT
C
S44°30'E
65.3FT
D
TRAVERSE #4
SCALE: 1"=60'
F
N19°30'W
153.2FT
S18°0'W
130.5FT
E

PART I — OPEN BEARING TRAVERSE

TRAVERSE	CLOSING	
	DISTANCE	BEARING
1	1305 FT	S35° 30'W
2	279.5 FT	S68° 0'W
3	398 FT	N77° 30'W
4	268 FT	N38° 30'E

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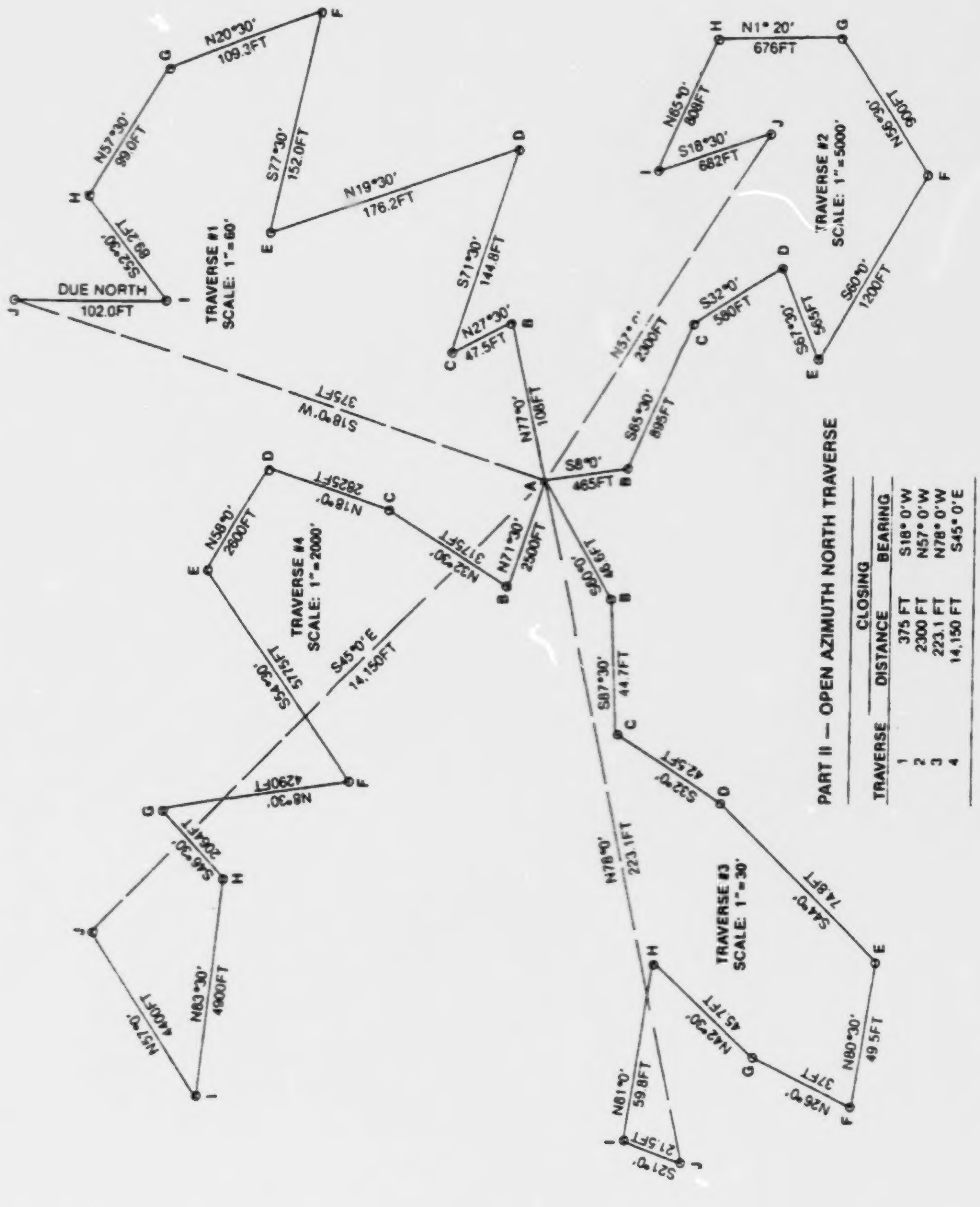
Part II: Open Azimuth North Traverses


TRAVERSE #1
SCALE: 1"=60'
DUE NORTH
102.0FT
S52°30'
89.2FT
N57°30'
99.0FT
N20°30'
109.3FT
S77°30'
152.0FT
N19°30'
176.2FT
S71°30'
144.8FT
N27°30'
47.5FT
N77°0'
108FT
S18°0'W
375FT
TRAVERSE #2
SCALE: 1"=5000'
S8°0'
465FT
S65°30'
895FT
S32°0'
580FT
S67°30'
565FT
S60°0'
1200FT
N56°30'
900FT
N1° 20'
676FT
N65°0'
808FT
S18°30'
682FT
N57°0'
2300FT
TRAVERSE #3
SCALE: 1"=30'
S60°0'
48.6FT
S87°30'
44.7FT
S32°0'
42.5FT
S44°0'
74.8FT
N80°30'
49.5FT
N26°0'
37FT
N42°30'
45.7FT
N81°0'
59.8FT
S21°0'
21.5FT
N78°0'
223.1FT
TRAVERSE #4
SCALE: 1"=2000'
N71°30'
2500FT
N32°30'
3175FT
N18°0'
2825FT
N58°0'
2600FT
S54°30'
5775FT
N8°30'
4290FT
S46°30'
2064FT
N83°30'
4900FT
N57°0'
4400FT
S45°0'E
14,150FT
A
B
C
D
E
F
G
H
I
J

PART II — OPEN AZIMUTH NORTH TRAVERSE

TRAVERSE	CLOSING	
	DISTANCE	BEARING
1	375 FT	S18° 0'W
2	2300 FT	N57° 0'W
3	223.1 FT	N78° 0'W
4	14,150 FT	S45° 0'E

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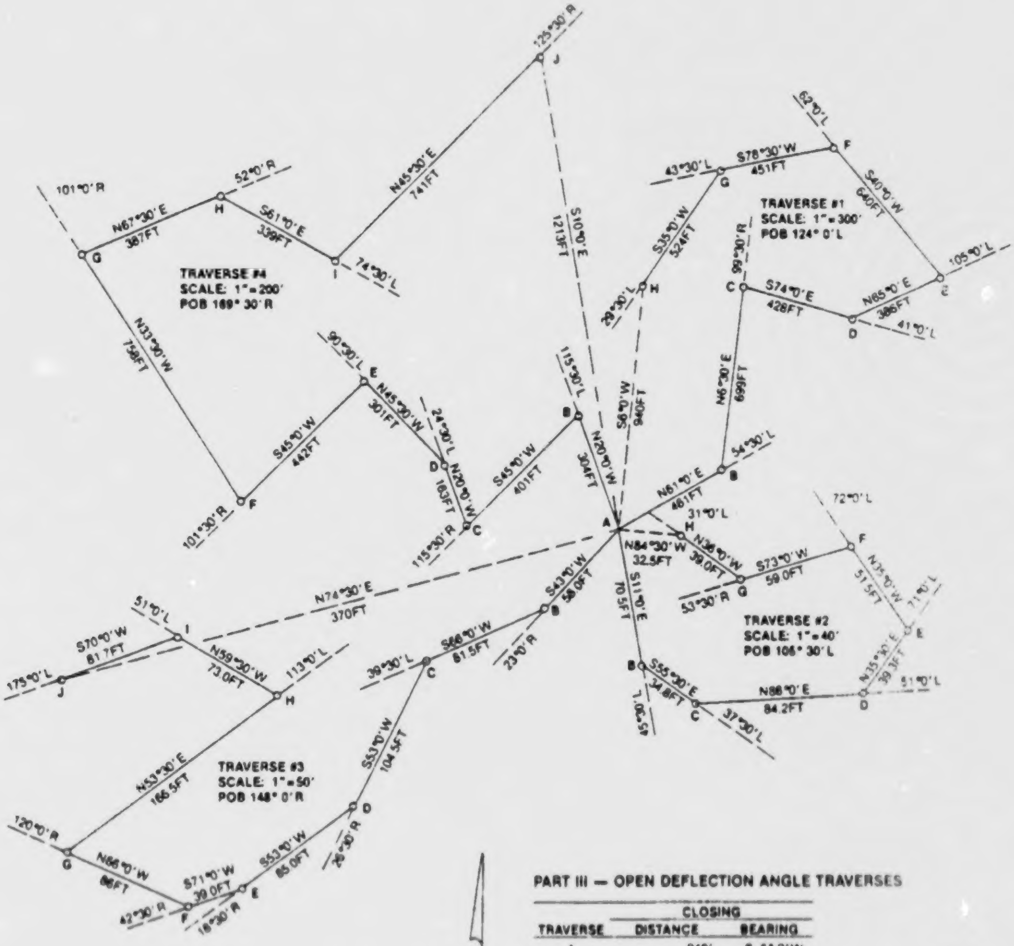
Answers to Assignment Sheets

Part III: Open Deflection Angle Traverses


TRAVERSE #1
SCALE: 1" = 300'
POB 124° 0'L
TRAVERSE #2
SCALE: 1" = 40'
POB 105° 30'L
TRAVERSE #3
SCALE: 1" = 50'
POB 148° 0'R
TRAVERSE #4
SCALE: 1" = 200'
POB 169° 30'R
A
B
C
D
E
F
G
H
I
J
125°30'R
101°0'R
N67°30'E
387FT
52°0'R
S61°0'E
339FT
74°30'L
N45°30'E
741FT
S10°0'E
1213FT
N33°30'W
758FT
101°30'R
S45°0'W
442FT
90°30'L
N45°30'W
301FT
24°30'L
N20°0'W
163FT
115°30'R
S45°0'W
401FT
115°30'L
N20°0'W
304FT
62°0'L
S78°30'W
451FT
43°30'L
S35°0'W
524FT
29°30'L
S6°0'W
940FT
S40°0'W
640FT
105°0'L
99°30'R
S74°0'E
428FT
N65°0'E
386FT
41°0'L
N6°30'E
699FT
54°30'L
N61°0'E
461FT
31°0'L
N84°30'W
32.5FT
N36°0'W
39.0FT
S73°0'W
59.0FT
53°30'R
72°0'L
N35°0'W
51.5FT
71°0'L
N35°30'E
39.3FT
51°0'L
N88°0'E
84.2FT
S55°30'E
34.8FT
37°30'L
S11°0'E
70.5FT
65°30'L
N74°30'E
370FT
S43°0'W
58.0FT
23°0'R
S66°0'W
81.5FT
39°30'L
S53°0'W
104.5FT
28°30'R
S53°0'W
85.0FT
16°30'R
S71°0'W
39.0FT
42°30'R
N66°0'W
86FT
120°0'R
N53°30'E
166.5FT
113°0'L
N59°30'W
73.0FT
51°0'L
S70°0'W
81.7FT
175°0'L

PART III — OPEN DEFLECTION ANGLE TRAVERSES

TRAVERSE	CLOSING DISTANCE	CLOSING BEARING
1	940'	S 6° 0'W
2	32.5'	N84° 30'W
3	370'	N74° 30'E
4	1213'	S10° 0'E

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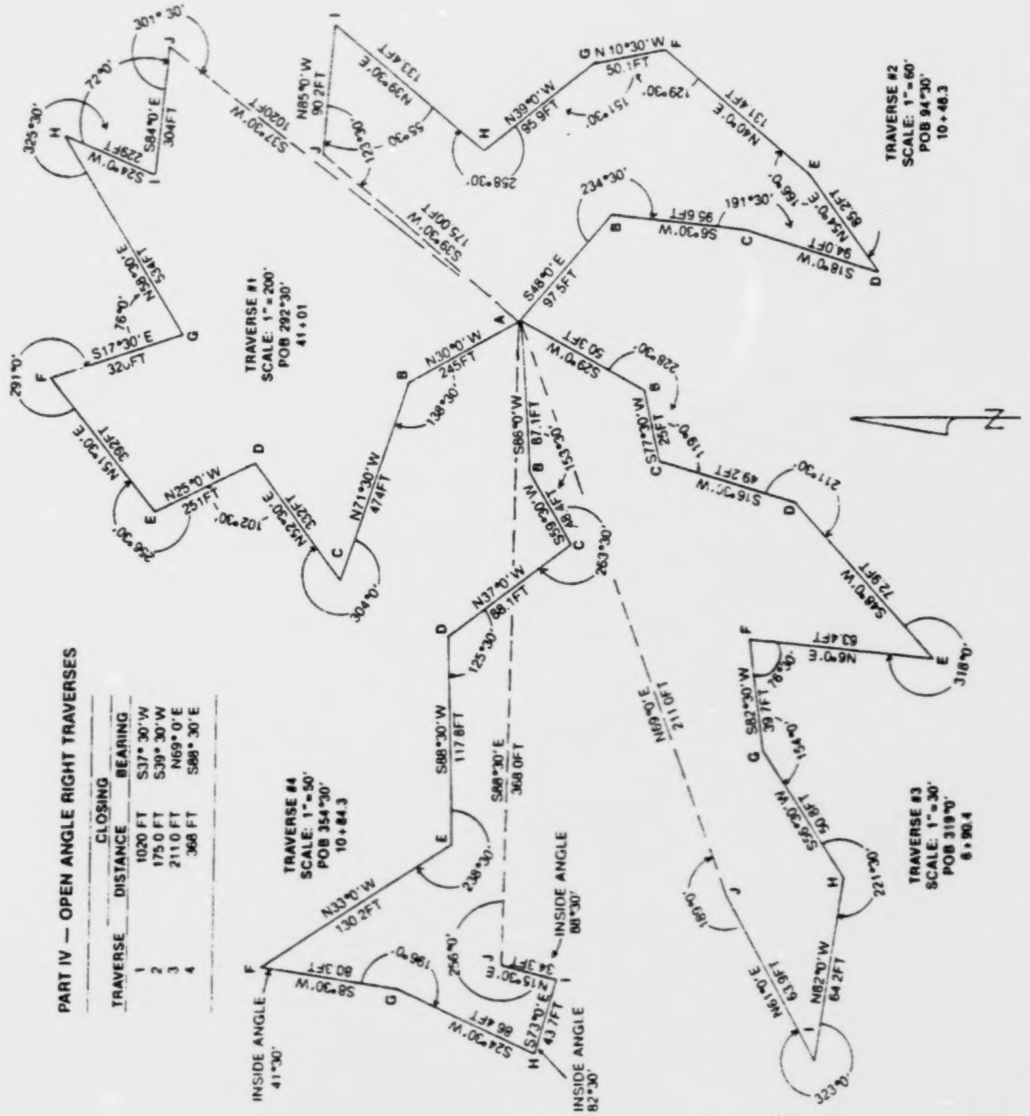
Answers to Assignment Sheets

Part IV: Open Angle Right Traverses


TRAVERSE #1
SCALE: 1" = 200'
POB 292°30'
41 + 01
A
B
N30°0'W
245FT
138°30'
C
N71°30'W
474FT
304°0'
N52°30'E
332FT
102°30'
D
E
N25°0'W
251FT
258°30'
N51°30'E
392FT
F
291°0'
S17°30'E
320FT
76°0'
G
N58°30'E
534FT
H
325°30'
S24°0'W
229FT
72°0'
I
S84°0'E
304FT
J
301°30'
S37°30'W
1020FT
TRAVERSE #2
SCALE: 1" = 60'
POB 94°30'
10 + 48.3
S48°0'E
97.5FT
B
234°30'
S6°30'W
95.6FT
C
191°30'
S18°0'W
94.0FT
D
N54°0'E
85.2FT
166°0'
E
N40°0'E
131.4FT
F
129°30'
G N10°30'W
50.1FT
151°30'
N39°0'W
85.9FT
H
258°30'
N39°30'E
133.4FT
55°30'
I
N85°0'W
90.2FT
J
123°30'
S39°30'W
175.00FT
TRAVERSE #3
SCALE: 1" = 30'
POB 319°0'
6 + 90.4
S29°0'W
50.3FT
B
228°30'
C S77°30'W
25FT
119°0'
S16°0'W
49.2FT
D
211°30'
S48°0'W
72.9FT
E
318°0'
N6°0'E
63.4FT
F
76°0'
S82°30'W
39.7FT
G
154°0'
S56°30'W
50.8FT
H
221°30'
N82°0'W
64.2FT
I
323°0'
N61°0'E
63.9FT
J
189°0'
N69°0'E
211.0FT
TRAVERSE #4
SCALE: 1" = 50'
POB 354°30'
10 + 84.3
S86°0'W
B
87.1FT
153°30'
S59°30'W
48.4FT
C
263°30'
N37°0'W
88.1FT
D
125°30'
S88°30'W
117.8FT
E
238°30'
N33°0'W
130.2FT
F
INSIDE ANGLE
41°30'
S8°30'W
80.3FT
G
196°0'
S24°30'W
86.4FT
H
INSIDE ANGLE
82°30'
S73°0'E
43.7FT
I
INSIDE ANGLE
88°30'
N15°30'E
34.3FT
J
256°0'
S88°30'E
368.0FT
N

PART IV — OPEN ANGLE RIGHT TRAVERSES

TRAVERSE	CLOSING DISTANCE	CLOSING BEARING
1	1020 FT	S37° 30'W
2	175.0 FT	S39° 30'W
3	211.0 FT	N69° 0'E
4	368 FT	S88° 30'E

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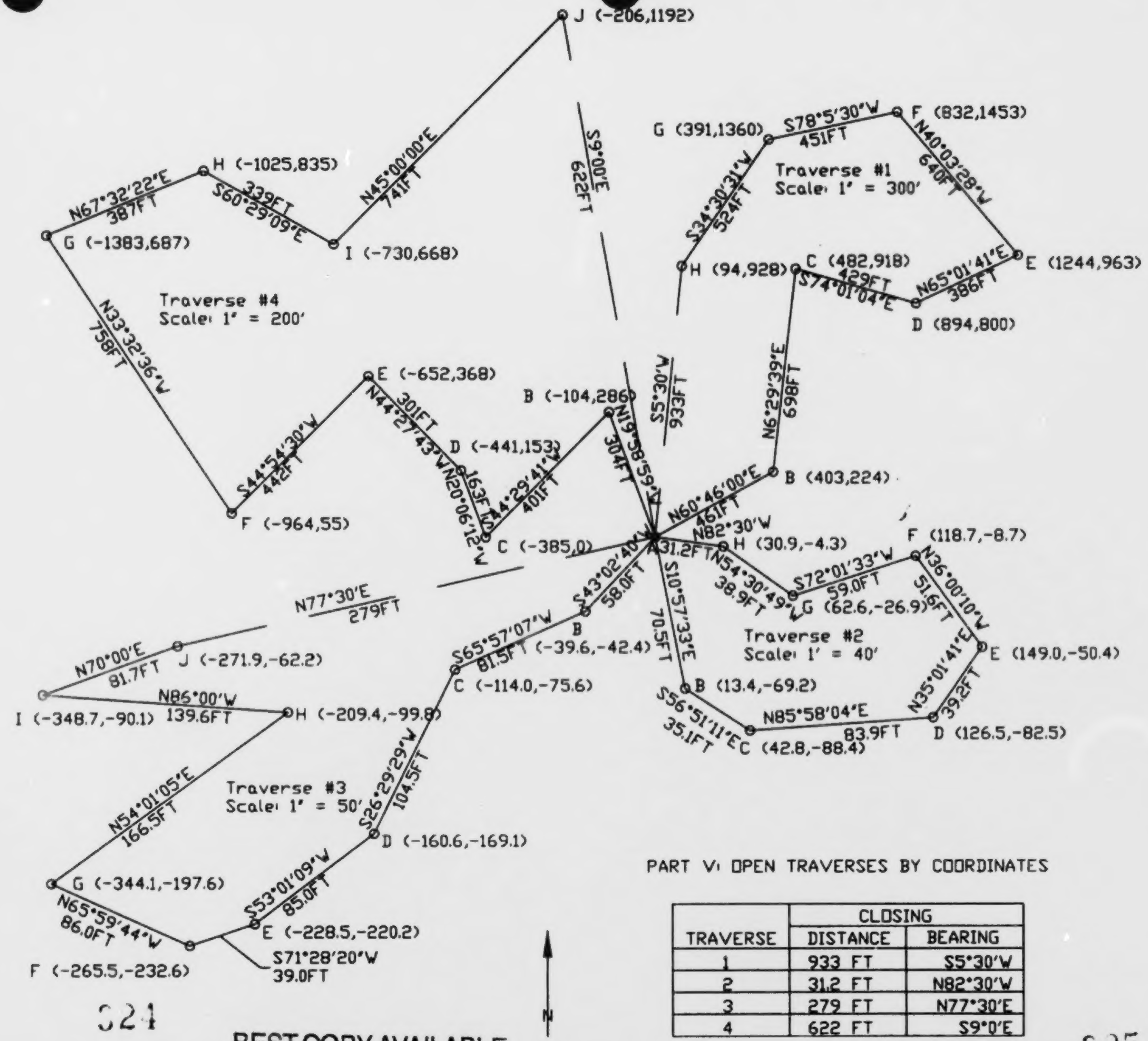
J (-206,1192)
S9°00'E
622FT
G (391,1360)
S78°5'30"W
451FT
F (832,1453)
N40°03'28"W
640FT
Traverse #1
Scale: 1" = 300'
S34°30'31"W
524FT
H (94,928)
C (482,918)
429FT
S74°01'04"E
N65°01'41"E
386FT
E (1244,963)
D (894,800)
N6°29'39"E
698FT
B (403,224)
N60°46'00"E
461FT
H (-1025,835)
N67°32'22"E
387FT
G (-1383,687)
S60°29'09"E
339FT
I (-730,668)
N45°00'00"E
741FT
Traverse #4
Scale: 1" = 200'
N33°32'36"W
758FT
E (-652,368)
N44°27'43"W
301FT
D (-441,153)
S44°54'30"W
442FT
F (-964,55)
N20°06'12"W
163FT
S44°29'41"W
401FT
C (-385,0)
B (-104,286)
N19°58'59"W
304FT
S5°30'W
933FT
A
31.2FT
N82°30'W
H (30.9,-4.3)
F (118.7,-8.7)
S72°01'33"W
59.0FT
N54°30'49"W
38.9FT
G (62.6,-26.9)
N36°00'10"W
51.6FT
E (149.0,-50.4)
Traverse #2
Scale: 1' = 40'
S10°57'33"E
70.5FT
B (13.4,-69.2)
S56°51'11"E
35.1FT
C (42.8,-88.4)
N85°58'04"E
83.9FT
D (126.5,-82.5)
N35°01'41"E
39.2FT
S43°02'40"W
58.0FT
B (-39.6,-42.4)
S65°57'07"W
81.5FT
C (-114.0,-75.6)
N77°30'E
279FT
N70°00'E
81.7FT
J (-271.9,-62.2)
I (-348.7,-90.1)
N86°00'W
139.6FT
H (-209.4,-99.8)
S26°29'29"W
104.5FT
D (-160.6,-169.1)
Traverse #3
Scale: 1' = 50'
N54°01'05"E
166.5FT
G (-344.1,-197.6)
N65°59'44"W
86.0FT
S53°01'09"W
85.0FT
E (-228.5,-220.2)
S71°28'20"W
39.0FT
F (-265.5,-232.6)
N

PART V: OPEN TRAVERSES BY COORDINATES

TRAVERSE	CLOSING	
	DISTANCE	BEARING
1	933 FT	S5°30'W
2	31.2 FT	N82°30'W
3	279 FT	N77°30'E
4	622 FT	S9°0'E

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Answers to Assignment Sheets

Part V: Continued

Traverse 1

Course	Length	Bearing
A-B	461	N 60°46′00″ E
B-C	698	N 06°29′39″ E
C-D	429	S 74°01′04″ E
D-E	386	N 65°01′41″ E
E-F	640	N 40°03′28″ W
F-G	451	S 78°05′30″ W
G-H	524	S 34°30′31″ W

Traverse 2

Course	Length	Bearing
A-B	70.5	S 10°57′33″ E
B-C	35.1	S 56°51′11″ E
C-D	83.9	N 85°58′04″ E
D-E	39.2	N 35°01′41″ E
E-F	51.6	N 36°00′10″ W
F-G	59.0	S 72°01′33″ W
G-H	38.9	N 54°30′49″ W

Traverse 3

Course	Length	Bearing
A-B	58.0	S 43°02′40″ W
B-C	81.5	S 65°57′07″ W
C-D	104.5	S 26°29′29″ W
D-E	85.0	S 53°02′09″ W
E-F	39.0	S 71°28′20″ W
F-G	86.0	N 65°59′44″ W
G-H	166.5	N 54°01′05″ E
H-I	72.9	N 58°58′08″ W
I-J	81.7	S 70°02′06″ W

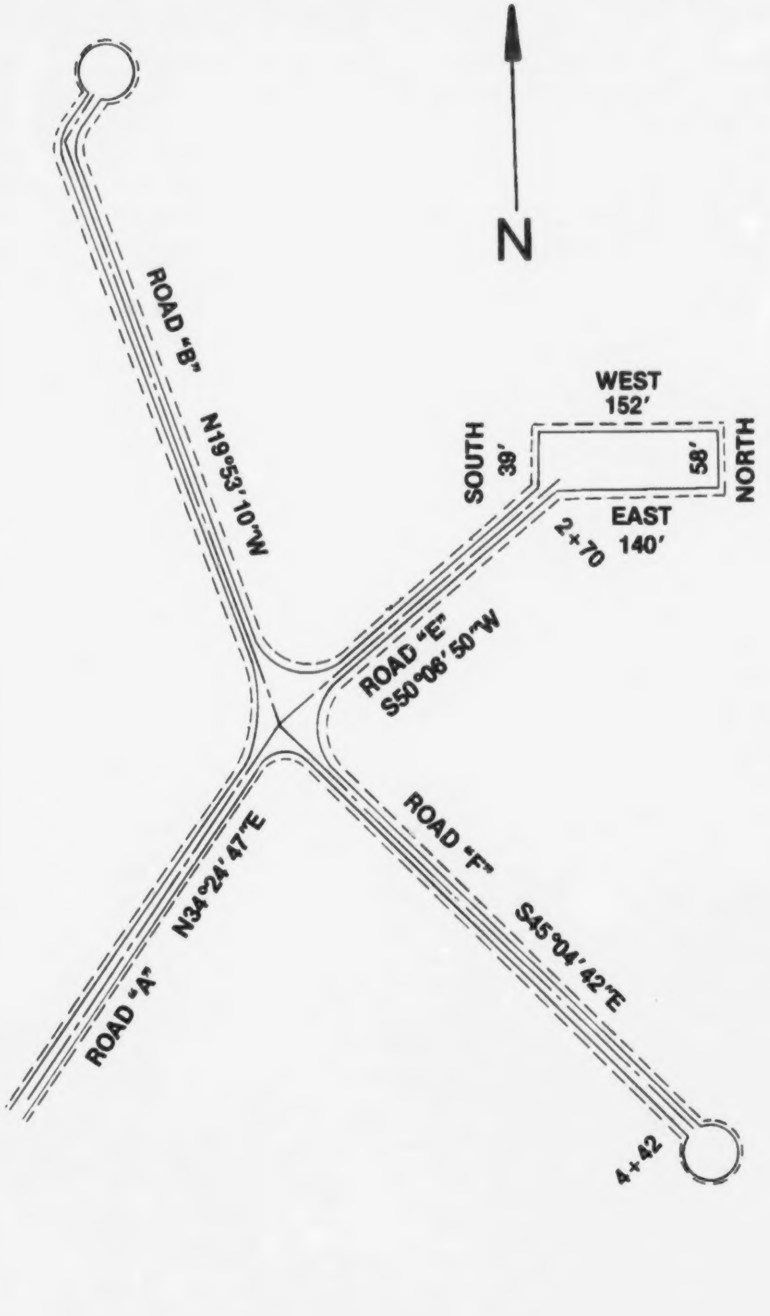
Traverse 4

Course	Length	Bearing
A-B	304	N 19°58′59″ W
B-C	401	S 44°29′41″ W
C-D	163	N 20°06′12″ W
D-E	301	N 44°27′43″ W
E-F	442	S 44°54′30″ W
F-G	758	N 33°32′36″ W
G-H	387	N 67°32′22″ E
H-I	339	S 60°29′09″ E
I-J	741	N 45°00′00″ E

	CLOSING	
TRAVERSE	DISTANCE	BEARING
1	933′	S 05°47′02″ W
2	31.2′	N 82°04′40″ W
3	360.2′	N 75°30′44″ E
4	1210′	S 09°48′18″ E

Assignment Sheet 2

Lay Out a Survey Alignment for a Road Using Bearings and Coordinates


N
ROAD "B"
N19°53'10"W
WEST
152'
SOUTH
39'
58'
NORTH
EAST
140'
2+70
ROAD "E"
S50°06'50"W
ROAD "F"
S45°04'42"E
ROAD "A"
N34°24'47"E
4+42

Answers to Assignment Sheets

Assignment Sheet 3

Calculate the Bearing, Slope, % Grade, True Length, and Azimuth of the ℄ of a Highway

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 4

Develop a Plan and Profile and Cross Sections, and Determine Cut and Fill for a Road Alignment

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms related to transportation mapping with their definitions. Definitions continue on the next page.

1. Angle of repose
2. Borrow pit
3. Catch slope
4. Central angle
5. Course
6. Curve length
7. Deflection angle
8. Degree of curve
9. Easement
10. Embankment
11. Excavation
12. Flag
13. Hub
14. Mass diagram
15. Match line
16. Modified proctor
17. Offset line
18. Point of curve
19. Right-of-way
20. Slope easement
21. Subgrade
22. Superelevation
23. Tangent
24. Transit line
25. Vertical curve

_____ a. A large one-sided arrow used for example to indicate the beginning and end of construction

_____ b. The line at the end of a mapped area which aids in fitting two drawings together

_____ c. A right acquired by public authority to use or control property for a designated purpose

_____ d. The intersection angle of a highway curve; also called the delta angle

_____ e. The slope of cut and fill from the road expressed in feet of horizontal run to feet of vertical run

_____ f. The legal right to cross the lands of another; used to indicate a strip of land for a road, railroad, or power line

_____ g. A pit or bank from which material is taken for use in filling or embanking at the construction site

_____ h. The length of highway curve from beginning to end measured along the arc

_____ i. The point at which a highway curve begins

_____ j. A drawing that shows the summary of earthwork over an entire project, including balance areas and quantities of earth grouped by soil classification, usually calculated by computer

_____ k. A line on a traverse

_____ l. The angle of a chord (from the preceding one) that connects station points along the centerline of a highway or railroad

_____ m. In surveying an angle that veers to the right or left of a straight line, often the centerline of a highway, power line, etc.

_____ n. The shape of a linear feature such as a road or highway (in profile) as it crests a hill or creates a sag in a valley or depression

_____ o. Adjusting the slope perpendicular to centerline for the purpose of counteracting centrifugal force

_____ p. The centerline of a linear survey (highway, pipeline, etc.)

_____ q. Straight line of a survey

_____ r. An easement for cut and fill

_____ s. A portion of a roadbed prepared as a foundation for the base or surface course

_____ t. A substantial square stake, usually driven flush with the ground, with a tack marking the survey point

_____ u. A supplementary line close to and roughly parallel with a main line, to which it is referenced by measured offsets

_____ v. Volume of material excavated from roadway cross section

_____ w. Soil test that determines the optimum compaction and moisture content range of the soil

_____ x. Volume of material (earth) needed for roadway construction

_____ y. Slope that connects the road base to the existing ground

Objective 2

State the purpose of route surveys.

____

____

Objective 3

Select true statements concerning the fundamentals of a route survey by placing an "X" in the blanks next to the true statements.

_____ a. The most common use for route surveys is for dam and reservoir location and construction.

_____ b. A closed traverse survey is the method recommended for use on route surveys.

_____ c. Traverses are first staked out as a series of straight lines.

_____ d. Curves are employed at the points of change in the traverse to allow for flow of travel.

Objective 4

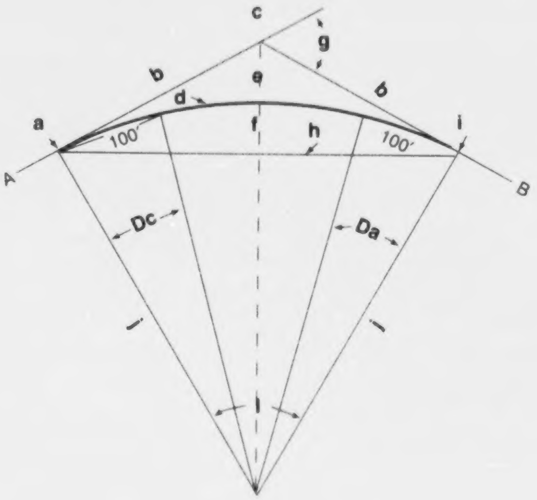
Complete the following statements concerning superelevated roadways by circling the correct answers.

a. A roadway is superelevated when the outside edge is **(lower, higher)** than the inside edge.

b. The purpose for superelevating a roadway is to allow for easy maneuvering of vehicles through **(horizontal, vertical)** curves.

Objective 5

Identify the following elements on the horizontal circular curve shown: R, PI, I or Δ, PC, PT, L, T, C, E, and M. Write your answers in the blanks provided.



a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

g. ______________________

h. ______________________

i. ______________________

j. ______________________

Objective 6

Complete the following mathematical formulas used for computing a horizontal curve.

a. $T = R \cdot \tan \frac{(\quad)}{2}$

b. $L = 100 \frac{I}{(\quad)}$

c. $\frac{D^\circ}{360^\circ} = 100 \frac{100}{2\pi (\quad)}$

Written Test

Objective 7

Select true statements concerning circular curve layout by tangent offsets by placing an "X" in the blanks next to the true statement(s).

______ a. Is used when precise layout of a curve is critical.

______ b. PC, PT, and the external point are still located by transit method.

______ c. Tangent offsets are used to locate intermediate points on the curve.

Objective 8

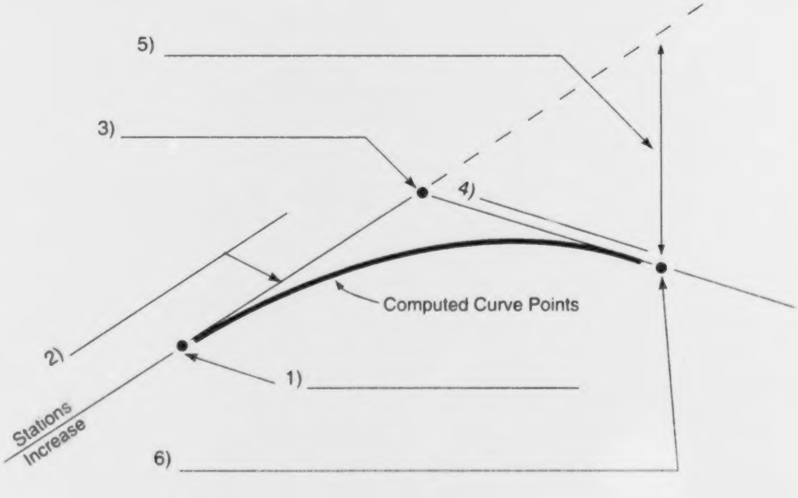
Complete the following statements concerning vertical curves by filling in the blanks with the correct answers.

a. Are the shapes of the road or highway as they ______________________.

b. The two general types are ________________ and sage.

c. Are calculated and the elevation points are plotted by _________________.

d. Locate the following points on the vertical curve shown: PVC, PVI, PVT, G_1, G_2, and H.



Objective 9

Complete the following statements concerning plan views for route surveys by filling in the blanks with the correct answers.

a. Are constructed from ____________________.

b. Show the following: (list five)

1) ____
2) ____
3) ____
4) ____
5) ____

c. Are placed in the ____________________ portion of the plan-profile paper.

d. Each sheet contains ____________ stations when the scale is 1" = 100 feet.

e. Each sheet should begin and end with ________________________.

Objective 10

Select true statements concerning characteristics of profiles for a route survey by placing an "X" in the blanks next to the true statements.

_____ a. Profiles are drawings showing cross sections along a certain survey line.

_____ b. Profiles are plotted from level notes or interpolated from the contour map.

_____ c. Level notes show elevations along the survey line.

_____ d. Profiles are plotted on standard plan-profile paper in the ungridded portion.

_____ e. The horizontal and vertical scales should be the same scale.

_____ f. Horizontal scale is exaggerated because the horizontal distances are greater as compared to the change in elevation.

_____ g. The preferred horizontal to vertical scale ratio is 50:1.

_____ h. Horizontal axis is twice the scale of the plan view.

_____ i. Only full stations are labeled and shown as tick marks on the accented grid lines.

_____ j. First station should be set over one grid line from the vertical scale.

_____ k. Station numbers increase from right to left.

_____ l. Station limits of the profile must correspond exactly to those of the plan portion of the sheet.

_____ m. Elevations for plotting profiles are obtained from the contour map in the plan view.

_____ n. Elevation data are indicated on both left and right sides of the sheet.

Written Test

Objective 11

Select true statements concerning characteristics of cross sections by placing an "X" in the blanks next to the true statements.

_____ a. Represent a cut 90° to the plan view and are used to show elevations.

_____ b. Are usually plotted on 50 units to the inch cross-section paper.

_____ c. Are arranged consecutively by stations which were reported in the field notes.

_____ d. Are usually plotted from bench level circuit field notes.

_____ e. Horizontal and vertical scales may or may not be the same.

_____ f. The scales used depend on the accuracy required in computing the cross-sectional areas and upon the relief.

_____ g. Cross sections are taken from the centerline out in each direction from the center line or taken out from the survey line of a street or borrow pit.

_____ h. Spacing of cross sections is determined by the engineers—the further apart, the more accurate the estimation of volume.

_____ i. Cut and fill areas should be cross hatched or shaded with the cut area and the fill area shaded the same.

Objective 12

Complete the following statements concerning field note reduction for a cross section by circling the correct answers.

a. **(Right, Left)** hand sheet shows notes used in determining the height of the instrument.

b. **(Right, Left)** hand sheet shows elevation points on which a reading was taken, the distance out from the control line, and the rod reading.

c. Only the distances and **(rod reading, elevation)** are used in plotting the cross section.

Objective 13

Complete the following statements concerning plotting cross sections by filling in the blanks with the correct answers.

a. Each section is plotted individually beginning at the top and ____________-hand side of sheet with station 0+00.

b. Sections are then plotted under each other in order of __________ numbers.

c. Each point on the cross section is plotted by using a ______________ scale for elevation and a __________ scale for the distance out.

d. Each point is labeled with coordinates. This coordinate number consists of a horizontal line with the distance out written on the ________________ and the elevation written on the ___________________.

e. A vertical scale different from that of the horizontal is used to accent the ___________________ _____________________.

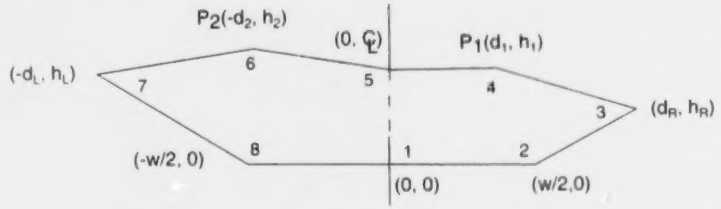
334

Objective 14

Distinguish among the three methods used to determine areas of cross sections by placing the following letter next to the correct illustrations and formulas:

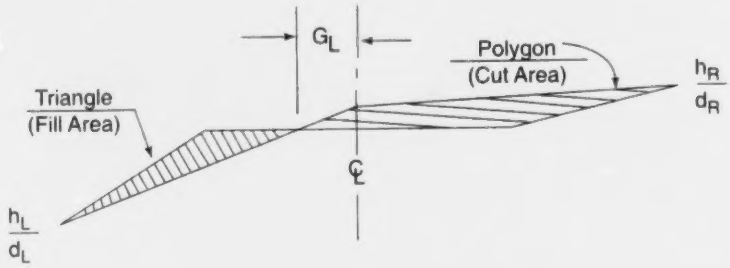
- X—Three-level section, pure cut **or** fill
- Y—Polygon section, pure cut **or** fill
- Z—Three-level section, cut **and** fill mixed

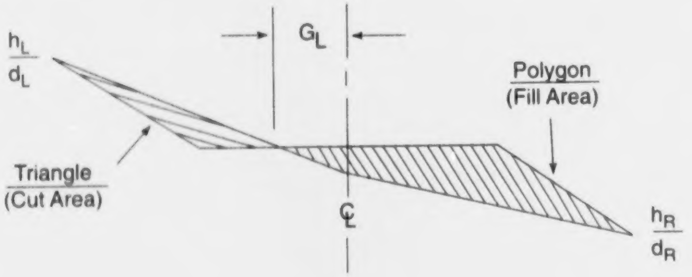
_____ a.


P2(-d2, h2)
(0, ℄)
P1(d1, h1)
(-dL, hL)
7
6
5
4
3
(dR, hR)
(-w/2, 0)
8
1
2
(0, 0)
(w/2,0)

$$A = (.5)\left[\frac{w}{2}(h_R + h_L) + d_1(\text{℄} - h_R) + d_2(\text{℄} - h_L) + d_R h_1 + d_L h_2\right]$$

_____ b.


GL
Polygon
(Cut Area)
Triangle
(Fill Area)
hR
dR
℄
hL
dL


hL
dL
GL
Polygon
(Fill Area)
Triangle
(Cut Area)
℄
hR
dR

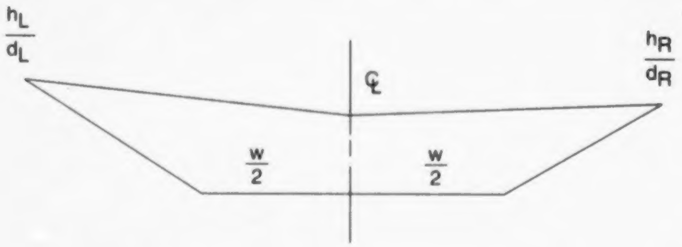
$$\text{Grade point } (G_L) = \frac{\text{℄}\, d_L}{h_L + \text{℄}}$$

$$A_\Delta = (.5)\frac{w}{2}h_L - \frac{\text{℄} d_L h_L}{h_L + \text{℄}}$$

$$A_P = (.5)\frac{w}{2}h_R + \text{℄} d_R + \frac{\text{℄}^2 d_L}{h_L + \text{℄}}$$

Written Test

_____ c.



$$\text{Area} = (.5)[\frac{W}{2}(h_L + h_R) + ℄\,(d_L + d_R)]$$

Objective 15

State the formula for calculating earth volume.

a. Volume by average end area: ______________________________

____

b. Volume by prismoidal method: ______________________________

____

c. Prismoidal correction: ______________________________

____

Objective 16

Arrange in order the following steps for a road construction project by placing the correct sequence numbers (1-9) in the blanks next to the steps.

_____ a. Field inspection review

_____ b. Engineer estimates—Bid prices are solicited for work to be done

_____ c. Showing—Show the contractor the job

_____ d. Develop a set of working plans

_____ e. Scoping—This is where the job is planned out; how to build it, how to manage the project

_____ f. Contract awarded—Work to be done to plans, project specials and M & S standards

_____ g. Environmental assessment—Public hearings are conducted and studies done to determine any concerns for the projected roadway

_____ h. Advertise for bids for construction

_____ i. Final office review—The final critique of the plans before starting the field work

Objective 17

List five drawings included in a set of highway plans.

a. ______

b. ______

c. ______

d. ______

e. ______

Objective 18

Select from the list below the common horizontal and vertical scales used in transportation mapping for rural and urban areas.

1″ = 1″
1″ = 1′
1″ = 5′
1″ = 10′
1″ = 20′
1″ = 25′
1″ = 40′
1″ = 50′
1″ = 100′
1″ = 150′

a. Rural areas

  1) Horizontal scale ______

  2) Vertical scale ______

b. Urban areas

  1) Horizontal scale ______

  2) Vertical scale ______

c. Sheet sizes

  1) 22″ x 34″ ______

  2) Half-size plan sheet ______

Objective 19

List four items that appear on a typical title sheet for a set of highway plans.

a. ______

b. ______

c. ______

d. ______

Written Test

Objective 20

Select true statements concerning detail sheets by placing an "X" in the blanks next to the true statements.

_____ a. Detail sheets show information necessary for constructing a special item.

_____ b. Each detail must be shown on a separate sheet.

_____ c. Details do not need to be arranged in any special order.

_____ d. Interchange details may have to be put on more than one sheet. Match lines are clearly marked on each sheet.

Objective 21

Complete the following statements concerning the drafting plan views, profiles, and cross sections by circling the correct words.

a. Drafting of plan views

1) Begin and end the sheet on stations divisible by **(five, ten)**.

2) Show projected alignment as **(dashed, solid)**.

3) Show right-of-way lines as long **(dash, solid)** line, then two short lines.

b. Drafting profiles

1) Correspond stations from the **(plan view, cross section)**.

2) Plot ground line under the roadway profile grade as a **(dotted, dashed)** line or light thin line.

3) Show elevations to the **(tenth, hundredth)** of a foot.

4) Show grades to the **(hundredth, thousandth, ten thousandth)** of a percent.

5) Arrange profile sheet with two inches left on bottom of sheet for the **(earthwork breakout, curve data)**.

c. Drafting cross sections

1) Draw in **(pen, pencil)** to facilitate changes.

2) Note scale and type of cross section at the upper **(left, right)**.

3) Write area of each section **(within, below)** the section and state if it is cut or fill.

4) Write volume of earth **(between the sections, in a chart at the bottom of the page)** and state if it is cut or fill.

5) Connect first and last points of each section by a **(dotted, dashed)** line.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 12
b. 15
c. 9
d. 4
e. 1
f. 19
g. 2
h. 6
i. 18
j. 14
k. 5
l. 8
m. 7
n. 25
o. 22
p. 24
q. 23
r. 20
s. 21
t. 13
u. 17
v. 11
w. 16
x. 10
y. 3

Objective 2

For making studies for the location and construction of such public utilities as highways, railways, pipelines, canals, and power lines

Objective 3

c, d

Objective 4

a. Higher
b. Horizontal

Objective 5

a. PC
b. T
c. PI
d. L
e. E
f. M
g. I or Δ
h. C
i. PT
j. R

Objective 6

a. /
b. D
c. R

Objective 7

b, c

Objective 8

a. Reach the top of a hill or bottom of a valley
b. Crests
c. Civil drafters
d. 1) PVC
   2) G_1
   3) PVI
   4) G_2
   5) H
   6) PVT

Answers to Written Test

Objective 9

a. Field notes
b. Any five of the following:
  1) Contours
  2) Survey alignment (transit line)
  3) Trees
  4) Buildings
  5) Other roads
  6) Cultivated areas
  7) Station points
  8) Curve (horizontal) data
  9) All necessary horizontal control (bearings, distances, radii, angles)
c. Ungridded
d. 30
e. Match lines

Objective 10

b, c, i, j, l, m, n

Objective 11

c, e, f, g

Objective 12

a. Left
b. Right
c. Elevation

Objective 13

a. Left
b. Station
c. Vertical, horizontal
d. Bottom, top
e. Elevation differentials

Objective 14

a. Y
b. Z
c. X

Objective 15

a. $V_E = L\left(\frac{A_1 + A_2}{2}\right)$

b. $V_P = \frac{L}{6}(A_1 + 4M + A_2)$

c. $V_C = V_E - V_P$

Objective 16

a. 4
b. 6
c. 8
d. 3
e. 2
f. 9
g. 1
h. 7
i. 5

Objective 17

Any five of the following:
Note: Others may be included in your area.

a. Title sheet
b. Standard plans list
c. Typical section and general notes
d. Estimate quantities
e. Structure quantities sheets
f. Tabulation sheets
g. Key map
h. Detail sheets
i. Removal or demolition and utility relocation
j. Pit location sheets
k. Major structure detail sheets
l. Plan and profile sheets (line sheets)
m. Cross section sheets
n. Landscaping and sprinkler plans
o. Roadway striping plans
p. Traffic control signs
q. Storm drainage plan and profile
r. Erosion control plans

Objective 18

a. 1) 1″ - 100′
   2) 1″ = 10′
b. 1) 1″ = 50′
   2) 1″ = 5′
c. 1) 1″ = 20′
   2) 1″ = 40′

Objective 19

Any four of the following:

a. Project number
b. State highway number
c. County and state
d. Location map
e. Length and design data
f. Index of sheets
g. Approval blocks

Objective 20

a, d

Objective 21

a. 1) Five
   2) Solid
   3) Dash
b. 1) Plan view
   2) Dashed
   3) Hundredth
   4) Ten thousandth
   5) Earthwork breakout
c. 1) Pencil
   2) Right
   3) Within
   4) Between the sections
   5) Dashed

Prerequisites: Units 1 through 7

Learning Activities Sheet

Student Name ____________________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objective 1, to familiarize yourself with common terms used in transportation mapping.

☐ 4. **Study** Information Sheet, Objectives 2 and 3, and Student Supplements 1 and 2.

☐ 5. **Do** Assignment Sheet 1, "Lay Out Open Traverses Using Several Methods"

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat Steps 5 and 6.

☐ 7. **Study** Information Sheet, Objective 4, and Student Supplement 3.

☐ 8. **Study** Information Sheet, Objectives 5 through 7, and Student Supplement 4.

☐ 9. **Study** Information Sheet, Objective 8, and Student Supplement 5.

☐ 10. **Study** Information Sheet, Objectives 9 and 10, and Student Supplement 6.

☐ 11. **Study** Information Sheet, Objectives 11 through 14, and Student Supplements 7 and 8.

☐ 12. **Study** Information Sheet, Objective 15.

☐ 13. **Study** Information Sheet, Objectives 16 through 21, and Student Supplements 9, 10 and 11.

Learning Activities Sheet

☐ 14. **Do** Assignment Sheet 2, "Lay Out a Survey Alignment for a Road Using Bearings and Coordinates."

☐ 15. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, repeat Steps 14 and 15.

☐ 16. **Do** Assignment Sheet 3, "Calculate the Bearing, Slope, % Grade, True Length, and Azimuth of the ℄ of a Highway."

☐ 17. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, repeat Steps 16 and 17.

☐ 18. **Do** Assignment Sheet 4, "Develop a Plan and Profile and Cross Sections, and Determine Cut and Fill For a Road Alignment."

☐ 19. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 20. If the evaluation is not satisfactory, repeat Steps 18 and 19.

☐ 20. **Check** With instructor for any additional assignments to be completed.

☐ 21. **Do** Additional assignments listed below.

____

____

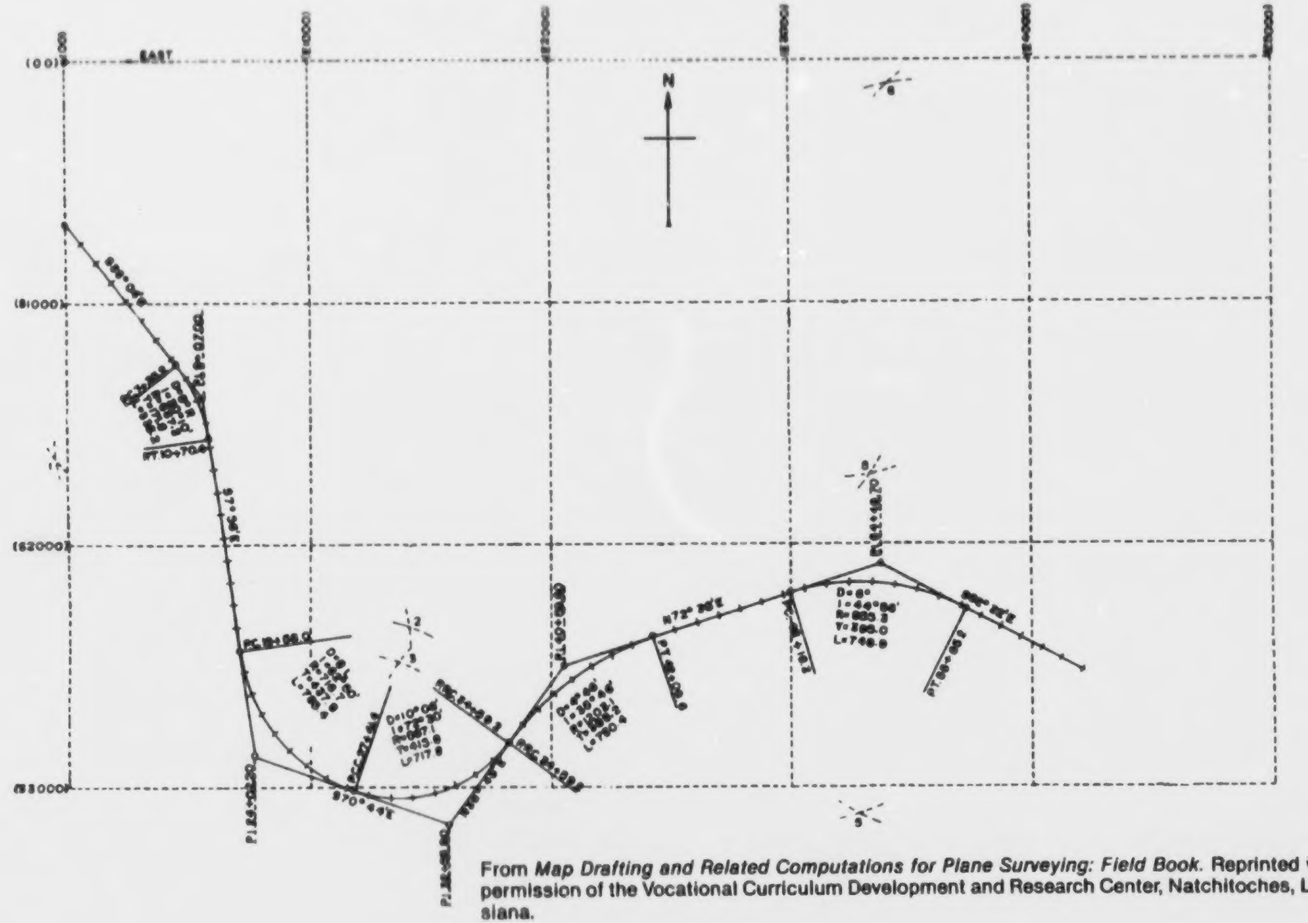
____

☐ 22. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 23. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Plotting a Traverse With Angles and Coordinates


EAST
(0 0)
(81000)
(82000)
(83000)
N
PT.10+70.4
PC.19+08.0
S70° 44'E
N72° 36'E
D=10° 00'
L=717.6
D=8°
L=748.0
2
3
5
6
8

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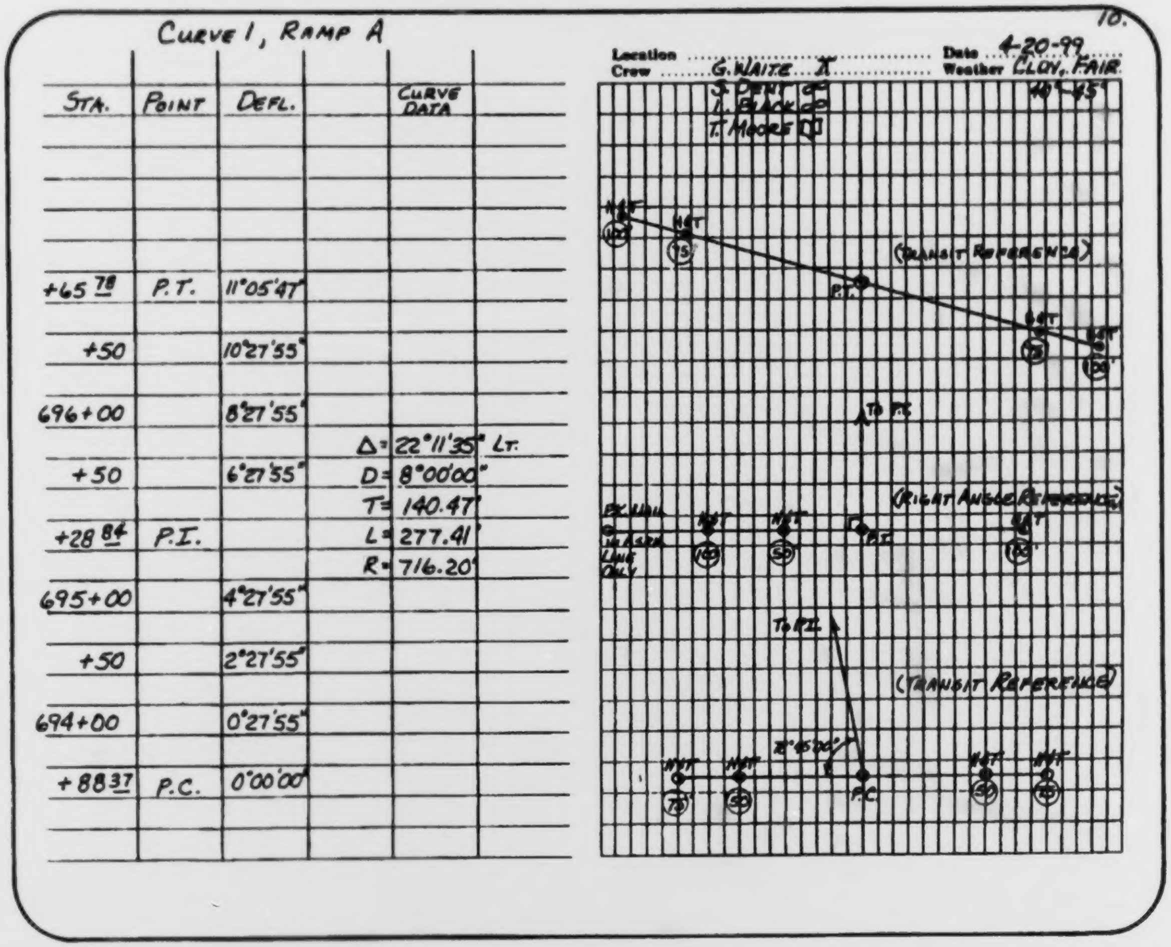
Field Notes for a Simple Curve



10.

Curve 1, Ramp A

Sta.	Point	Defl.		Curve Data	
+65$^{\underline{78}}$	P.T.	11°05'47"			
+50		10°27'55"			
696+00		8°27'55"			
			Δ=	22°11'35"	Lt.
+50		6°27'55"	D=	8°00'00"	
			T=	140.47'	
+28$^{\underline{84}}$	P.I.		L=	277.41'	
			R=	716.20'	
695+00		4°27'55"			
+50		2°27'55"			
694+00		0°27'55"			
+88$^{\underline{37}}$	P.C.	0°00'00"			

Location ....

Date 4-20-99

Crew G. Waite ⊼

S. Dent ⌀

I. Black ⌀

T. Moore ☐

Weather Clov, Fair 40°-45°

H&T
100'
H&T
75'
(Transit Reference)
P.T.
H&T
75'
H&T
100'
To P.C.
(Right Angle Reference)
Ex. Wall
Ht. Asph.
Line Only
H&T
100'
H&T
50'
P.I.
H&T
100'
To P.I.
(Transit Reference)
2°45'00"
H&T
75'
H&T
50'
P.C.
H&T
50'
H&T
75'

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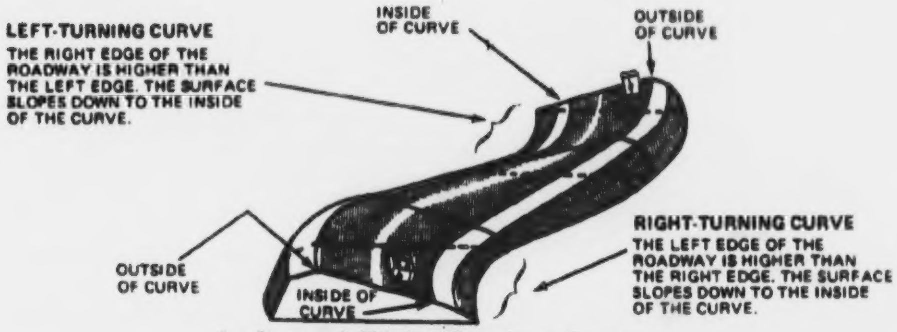
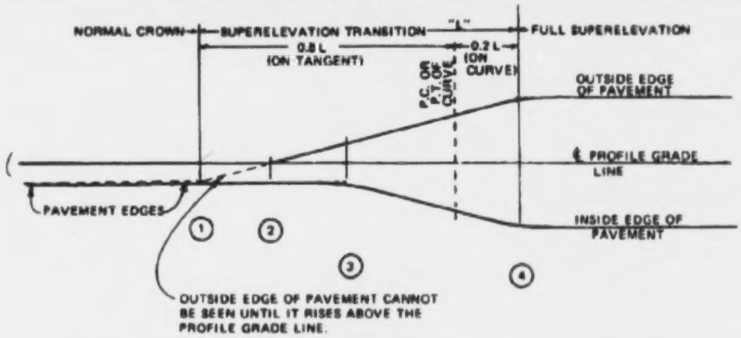
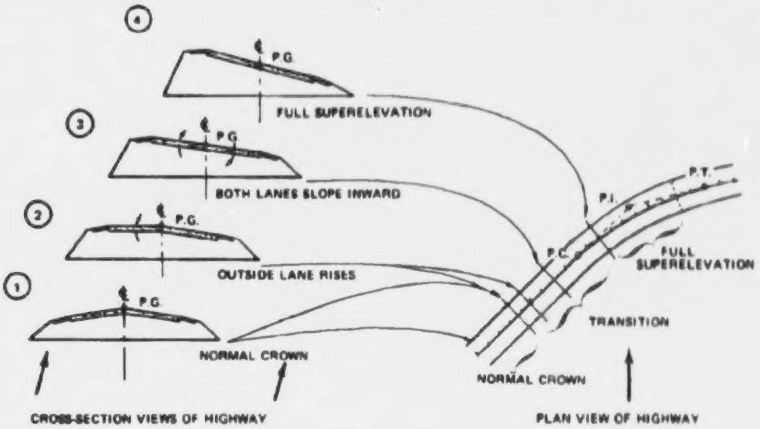
Superelevations of a Roadway


LEFT-TURNING CURVE
THE RIGHT EDGE OF THE ROADWAY IS HIGHER THAN THE LEFT EDGE. THE SURFACE SLOPES DOWN TO THE INSIDE OF THE CURVE.
INSIDE OF CURVE
OUTSIDE OF CURVE
OUTSIDE OF CURVE
INSIDE OF CURVE
RIGHT-TURNING CURVE
THE LEFT EDGE OF THE ROADWAY IS HIGHER THAN THE RIGHT EDGE. THE SURFACE SLOPES DOWN TO THE INSIDE OF THE CURVE.

Left- and Right-Turning Curves


NORMAL CROWN
SUPERELEVATION TRANSITION
"L"
FULL SUPERELEVATION
0.8 L
(ON TANGENT)
0.2 L
(ON CURVE)
P.C. OR P.T. OF CURVE
OUTSIDE EDGE OF PAVEMENT
℄ PROFILE GRADE LINE
PAVEMENT EDGES
INSIDE EDGE OF PAVEMENT
①
②
③
④
OUTSIDE EDGE OF PAVEMENT CANNOT BE SEEN UNTIL IT RISES ABOVE THE PROFILE GRADE LINE.

Profile View of a Superelevation Transition


④
℄ P.G.
FULL SUPERELEVATION
③
℄ P.G.
BOTH LANES SLOPE INWARD
②
℄ P.G.
OUTSIDE LANE RISES
①
℄ P.G.
NORMAL CROWN
CROSS-SECTION VIEWS OF HIGHWAY
P.T.
P.I.
P.C.
FULL SUPERELEVATION
TRANSITION
NORMAL CROWN
PLAN VIEW OF HIGHWAY

Cross-Section and Plan Views of a Highway in Superelevation

From *Civil Engineering Drafting* by Roy H. and James R. Wirshing. ©1983. Reproduced with permission of Glencoe/McGraw-Hill.

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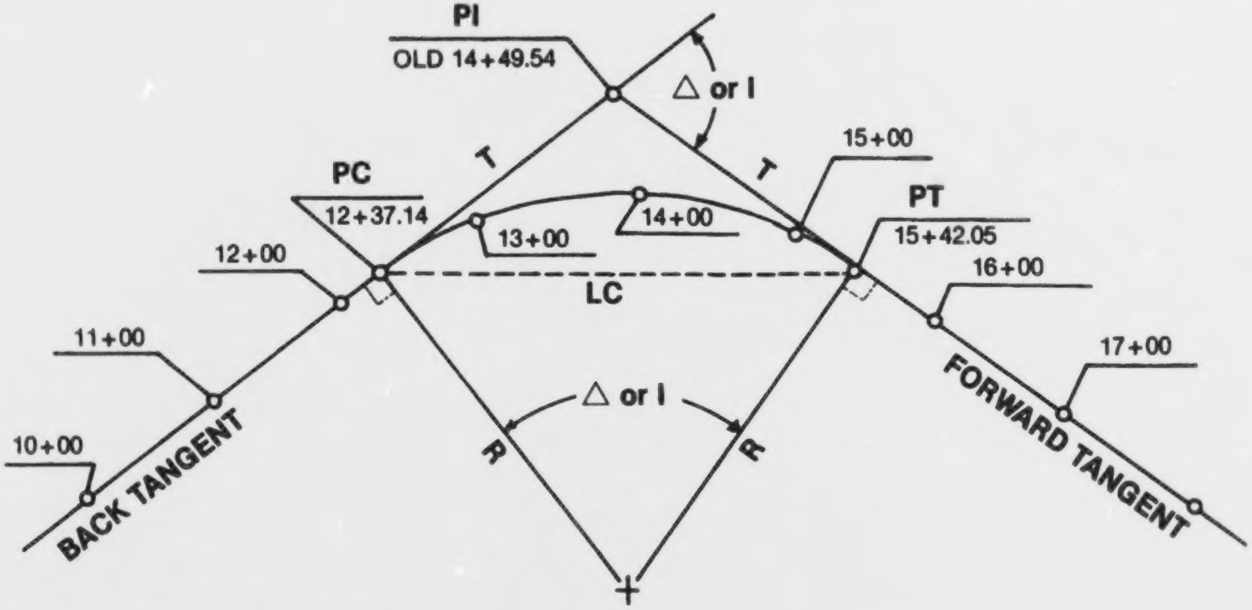
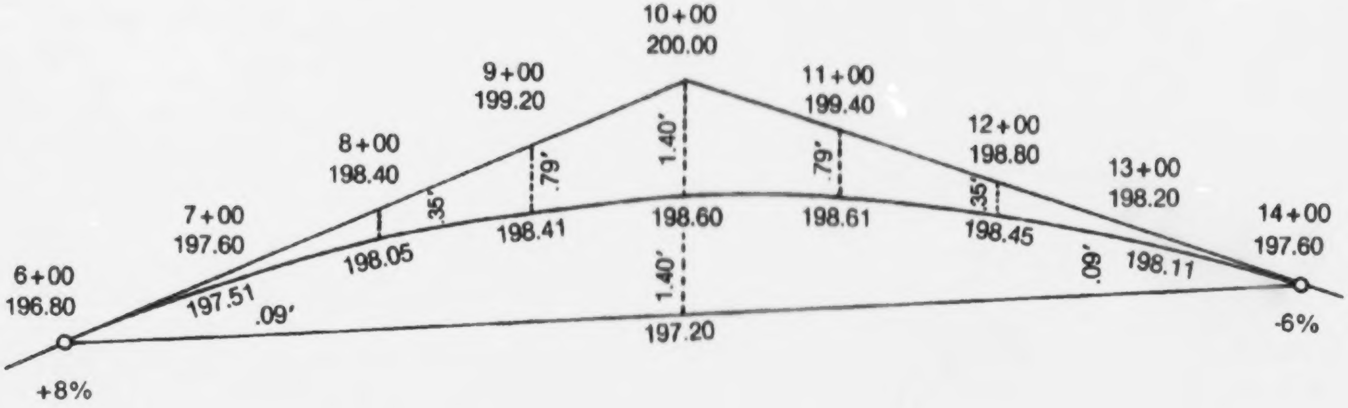
Horizontal Curve

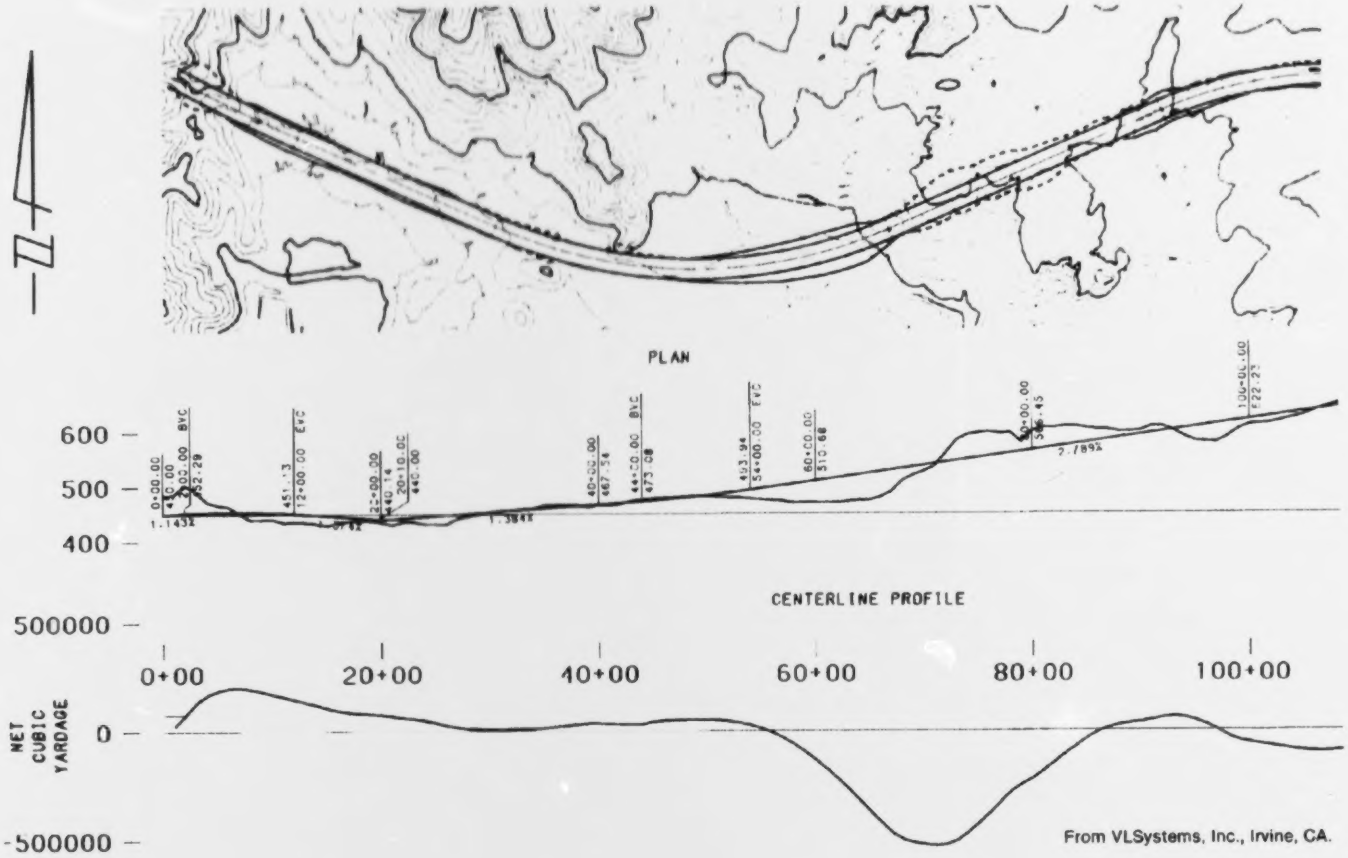

PI
OLD 14+49.54
△ or I
T
T
15+00
PC
12+37.14
14+00
13+00
PT
15+42.05
12+00
LC
16+00
11+00
17+00
△ or I
10+00
BACK TANGENT
R
R
FORWARD TANGENT

Vertical Curve


10+00
200.00
9+00
199.20
11+00
199.40
8+00
198.40
12+00
198.80
7+00
197.60
13+00
198.20
6+00
196.80
14+00
197.60
1.40'
.79'
.79'
.35'
.35'
198.60
198.41
198.61
198.05
198.45
197.51
.09'
.09'
198.11
1.40'
197.20
+8%
-6%

STATION	6=A	7	8	9	10	11	12	13	14=C
Elevation of Tangent	196.80	197.60	198.40	199.20	200.00	199.40	198.80	198.20	197.60
Tangent Offset	0.00	.09	.35	.79	1.40	.79	.35	.09	0.00
Elevation of Curve	196.80	197.51	198.05	198.41	198.60	198.61	198.45	198.11	197.60

Example of a Plan and Profile


PLAN
600
500
400
0+00.00
430.00
2+00.00 BVC
452.29
1.143%
451.13
12+00.00 EVC
22+00.00
440.14
20+10.00
440.00
1.384%
40+00.00
467.54
44+00.00 BVC
473.08
493.94
54+00.00 EVC
60+00.00
510.68
2.789%
100+00.00
622.23
CENTERLINE PROFILE
500000
0+00
20+00
40+00
60+00
80+00
100+00
NET CUBIC YARDAGE
0
-500000

From VLSystems, Inc., Irvine, CA.

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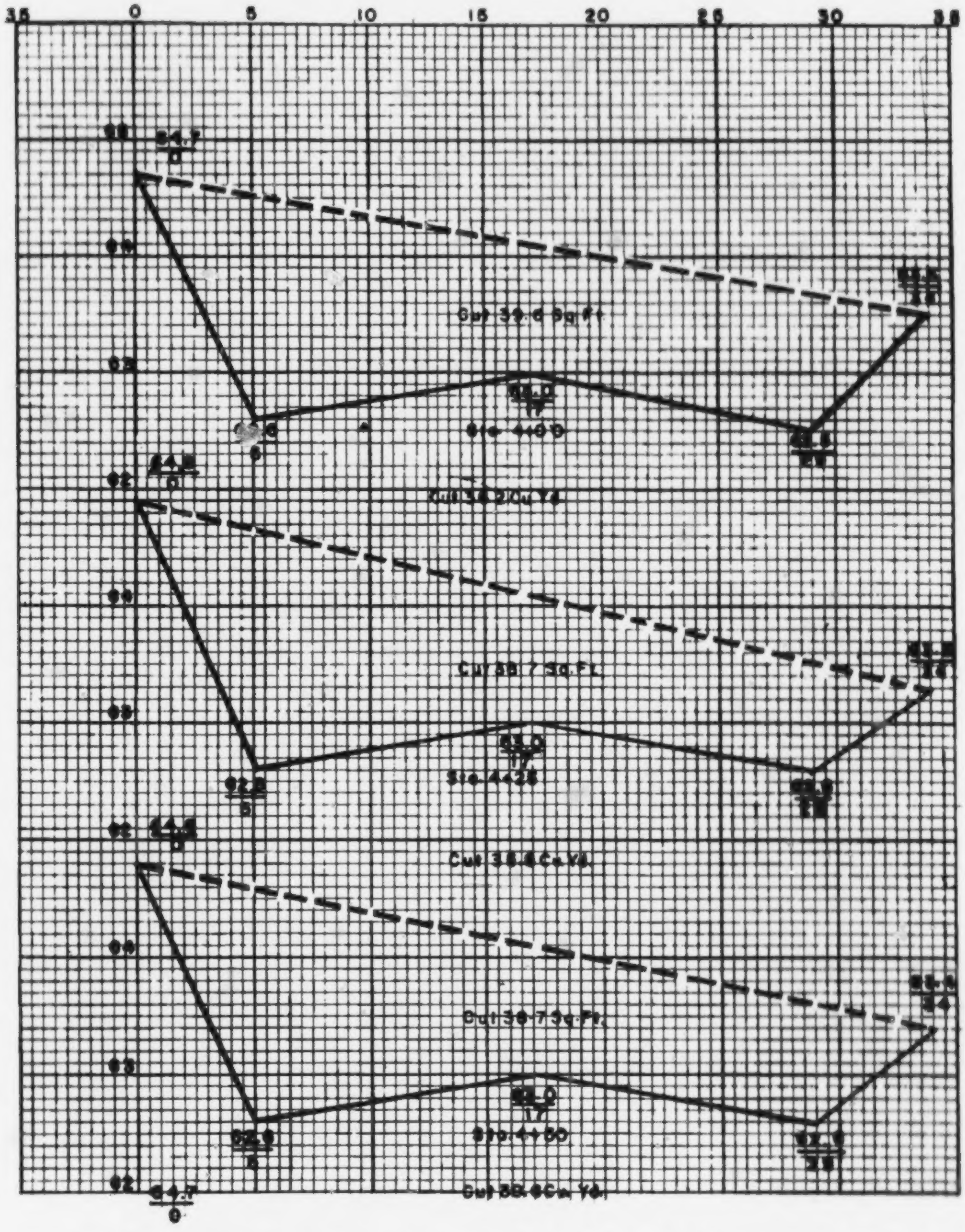
Example of Cross Sections



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Field Notes for Cross Sections

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50

Cross-Sections King Street

Sta	B.S.	H.I.	F.S.	Elev.	
B.M.	4.7	68.3		63.6	
					(Elev.)
0+00					(Dist.)
					(Rod)
0+25					
0+50					
0+75					
1+00					
1+25					

J. Zerangue, ⊼
G. Carrier, Rod
M. LeBlanc, Tape
July 14, 1964
Clear - Warm

61.5	59.8	60.0	59.7	61.3
0	5	17	29	34
6.8	8.5	8.3	8.6	7.0
62.4	60.2	60.4	60.0	61.5
0	5	17	29	34
5.9	8.1	7.9	8.3	6.8
63.2	60.4	60.8	60.4	61.8
0	5	17	29	34
5.1	7.9	7.5	7.9	6.5
63.8	60.4	61.0	60.6	61.3
0	5	17	29	34
4.5	7.9	7.3	7.7	7.0
63.8	60.8	61.2	60.8	63.0
0	5	17	29	34
4.5	7.5	7.1	7.5	5.3
64.1	61.0	61.4	60.9	63.3
0	5	17	29	34
4.2	7.3	6.9	7.4	5.0

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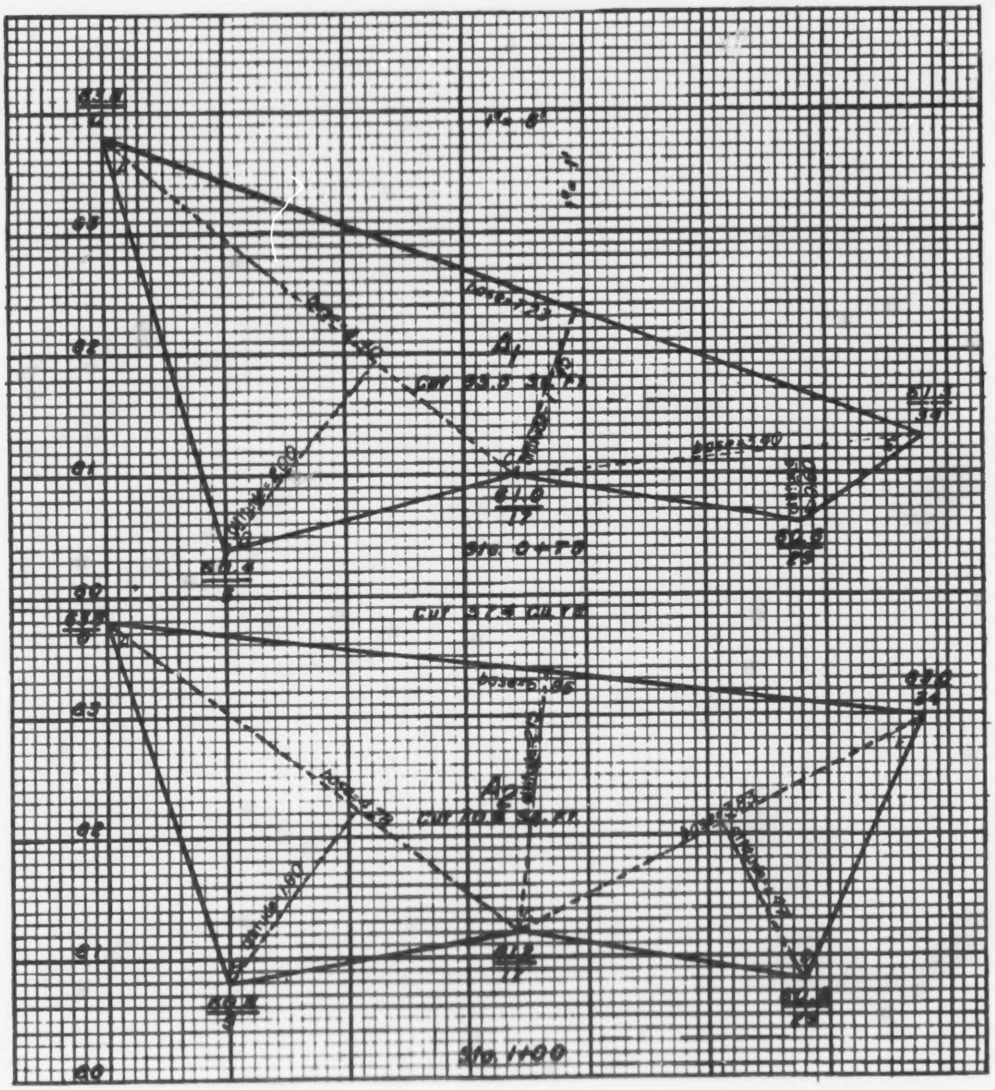
Areas of Cross Sections


1" = 8'
A1
Sta. 0+50
Cut 37.5 cu. yd.
A2
Sta. 1+00
63
62
61
60

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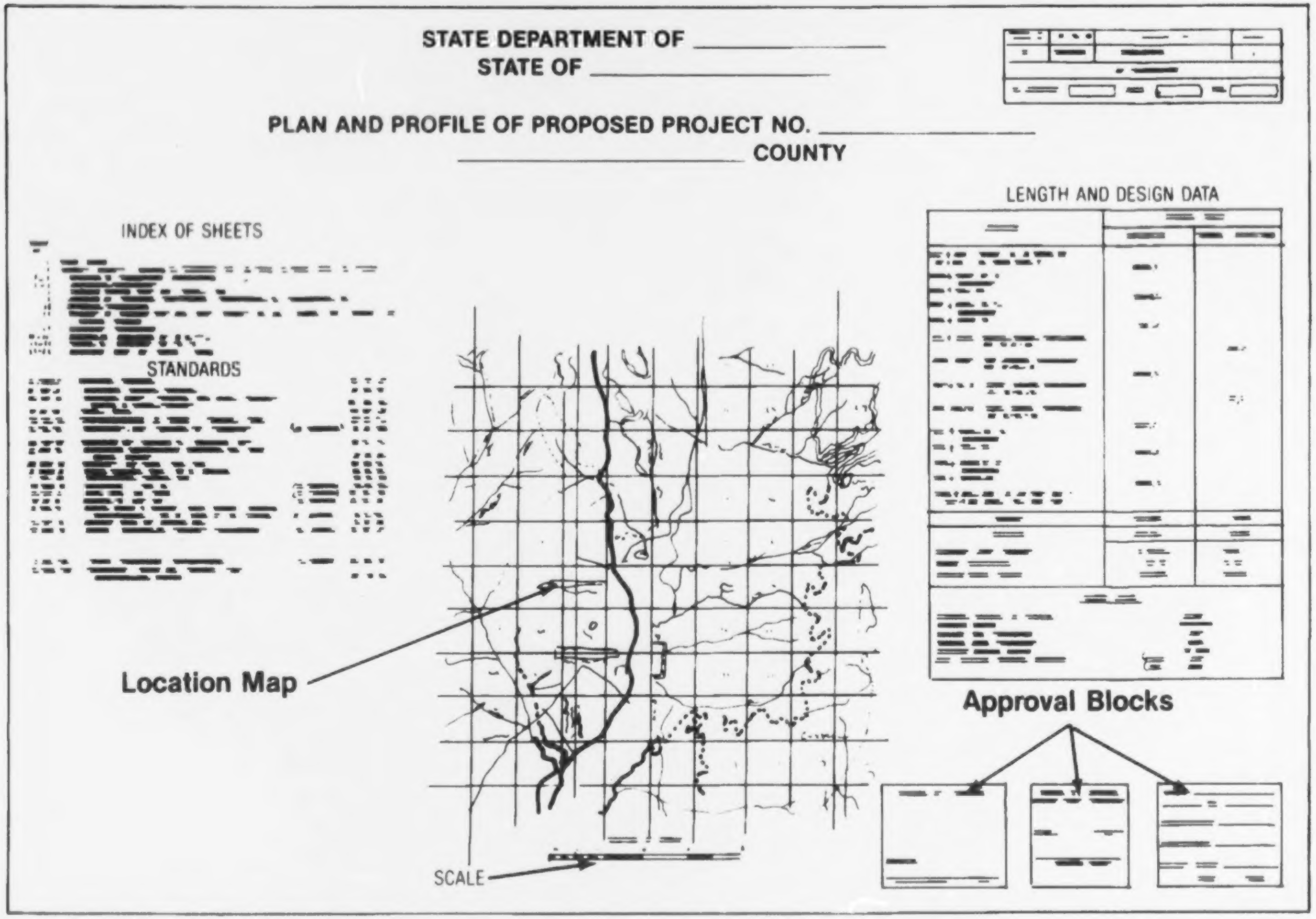
Typical Title Sheet


STATE DEPARTMENT OF ________________
STATE OF ________________
PLAN AND PROFILE OF PROPOSED PROJECT NO. ________________
________________ COUNTY
INDEX OF SHEETS
STANDARDS
LENGTH AND DESIGN DATA
Location Map
Approval Blocks
SCALE

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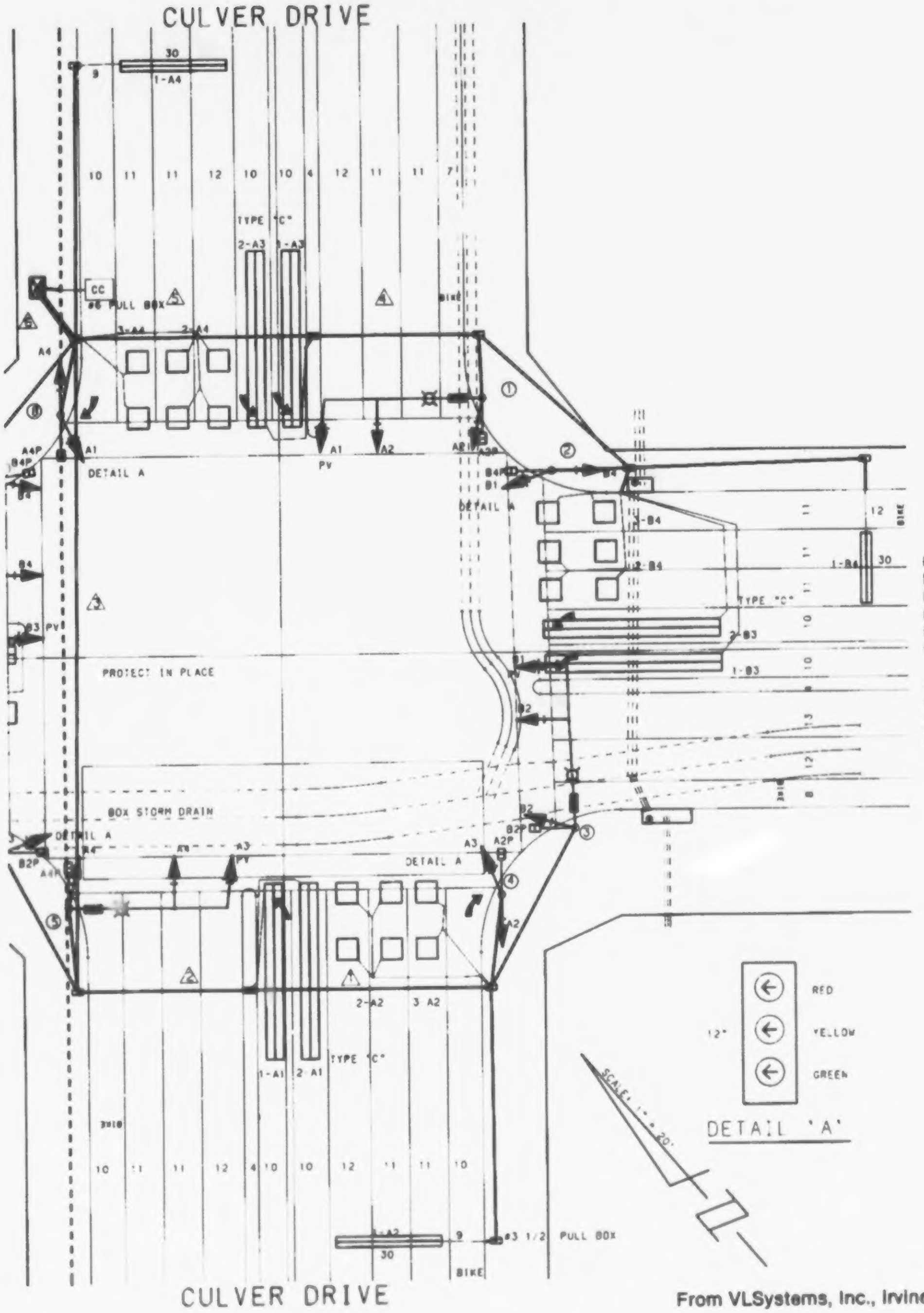
Example of a Highway Detail
(Traffic Signal Plan)


CULVER DRIVE
MAIN STREET
CULVER DRIVE
30
1-A4
10 11 11 12 10 10 4 12 11 11 7
TYPE "C"
2-A3
1-A3
CC
#6 PULL BOX
3-A4
2-A4
BIKE
A4
A1
A1
PV
A2
A4P
B4P
DETAIL A
B1
B4
1-B4
2-B4
1-B4
30
12
11
10
TYPE "C"
2-B3
1-B3
B3 PV
PROTECT IN PLACE
B2
BOX STORM DRAIN
DETAIL A
A3
A3 PV
A2P
B2P
2-A2
3 A2
TYPE "C"
1-A1
2-A1
10 11 11 12 4 10 10 12 11 11 10
1-A2
30
9
#3 1/2 PULL BOX
BIKE
RED
YELLOW
GREEN
12"
DETAIL 'A'
SCALE: 1" = 20'

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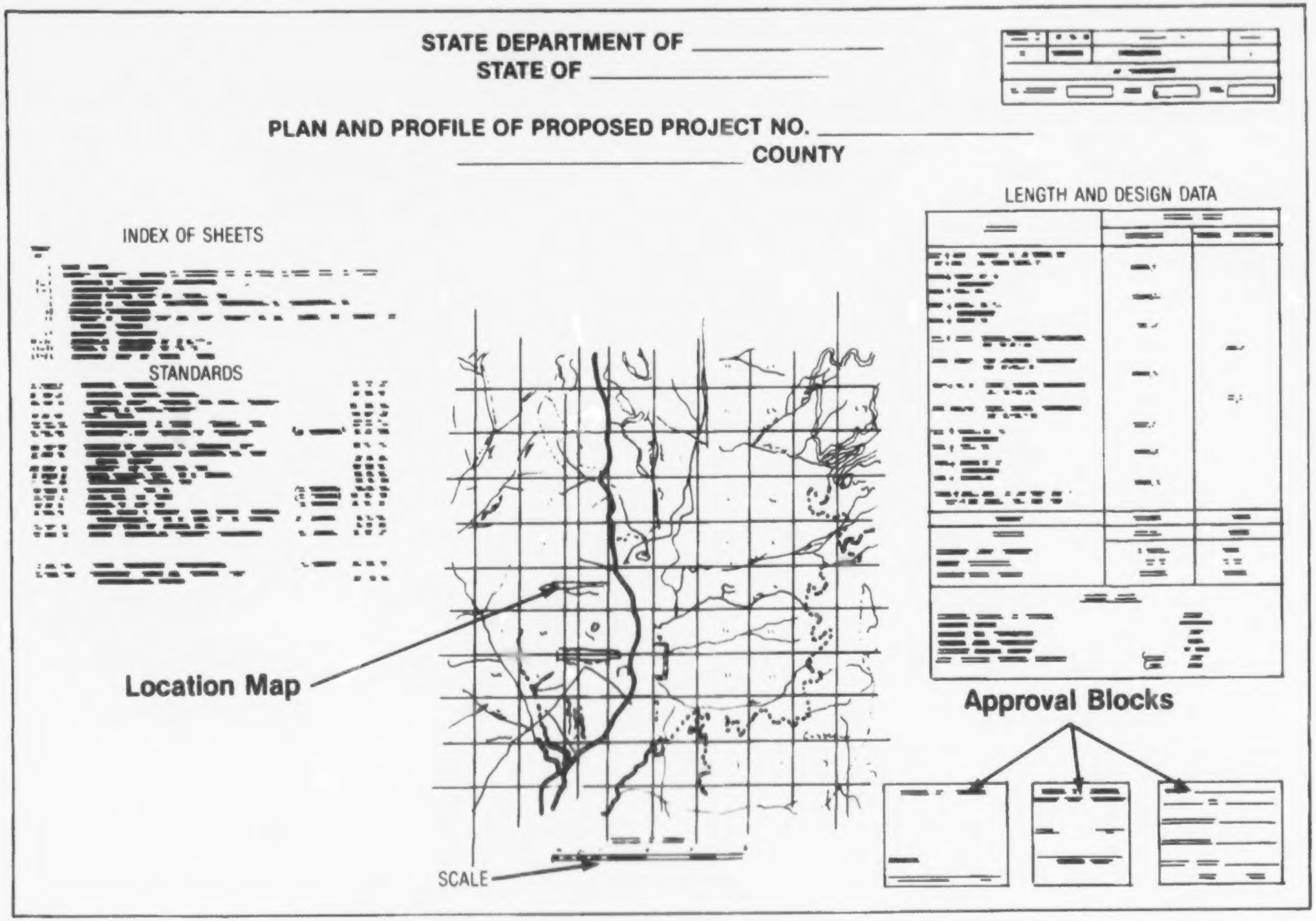
Typical Plan and Profile


STATE DEPARTMENT OF
STATE OF
PLAN AND PROFILE OF PROPOSED PROJECT NO.
COUNTY
INDEX OF SHEETS
STANDARDS
LENGTH AND DESIGN DATA
Location Map
Approval Blocks
SCALE

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Student Components

Student Page

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Assignment Sheets

1—Prepare Detail Drawings of Structural Steel Members 10–61
2—Draw to Scale a Concrete Engineering Drawing 10–63
3—Detail a Wood Truss 10–67

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Visit a construction site and observe the various methods of construction for wood, steel, and concrete.
- Review MAVCC publications on architectural and light construction for standards on light frame construction.
- Provide examples of actual structural details and engineering drawings used in structural drafting.
- Take a field trip to a large civil engineering firm to see how the structural drafter fits in with civil drafting.
- Provide copies of the AISC and ACI manuals to students for use on the assignment sheets.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- Alpine Truss *Architectural Engineering Manual.* Pompano Beach, FL.
- American Concrete Institute
  P.O. Box 19150
  Detroit, MI 48219
  - — *Detailing Manual, Publication SP-66*
  - — *Building Code Requirements for Reinforced Concrete*
  - — *Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete*

567

- American Institute of Steel Construction (AISC)
  400 North Michigan Avenue
  Chicago, IL 60611

  — *Manual of Steel Construction*
  — *Structural Steel Detailing*
  — *Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings*

- *Drafting Manual*. Public Service Company of Oklahoma, Tulsa, OK.

- Steel Beam Design for Windows, Eagle Point Software
  4131 Westmark Drive
  Dubuque, IA 52002
  www.eaglepoint.com
  1-800-678-6565, Ext. 549

- *Encyclopedia of Trusses*. St. Louis, MO: Lumbermate Co.

- Goetsch, David L. *Structural Drafting*, 2nd ed. New York: Delmar Publishing, Inc., 1994. ISBN 0-8273-6302-8.

- *Heavy Timber Construction Details*, National Lumber Manufacturers Association, Washington, D.C.

- Jensen, Cecil Howard and Jay O. Helsel. *Engineering Drawing and Design*, 5th ed. New York: McGraw-Hill Book Co., 1997.

- *Timber Construction Manual*. American Institute of Timber Construction (AITC), 333 W. Hampton Avenue Englewood, CO

- Truss Plate Institute (TPI)
  100 West Church Street
  Frederick, MD 21701

- *Typical Designs of Timber Structures*. Timber Engineering Co., Washington, D.C.

Answers to Assignment Sheets

Assignment Sheet 1

Prepare Detail Drawings of Structural Steel Members

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 2

Draw to Scale a Concrete Engineering Drawing

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 3

Detail a Wood Truss

Part A

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Part B

Step 1. 56′0″ length ÷ 2 = 28′

Step 2. 28 + 1 = 29

Step 3. 20 – 2 Gable Ends = 27

Answer: 27 trusses

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms related to structural drafting with their definitions. Terms and definitions continue on the next two pages.

1. Bay
2. Bottom chord
3. Chord
4. Compression
5. Flange
6. Gage line
7. Lintel
8. Panel
9. Rafter
10. Rebar
11. Smooth bar
12. Stress

_____ a. A short term to define a round, square, or deformed bar used to reinforce concrete

_____ b. A structural member designed to carry the wall over a window, door, or other opening

_____ c. A force caused by loads being placed on a member that causes a squeezing or shortening effect on the member

_____ d. The line along which fastener holes are punched or drilled in structural members

_____ e. The wood members used to support the roof in conventional framing

_____ f. The space between two consecutive sets or tiers of columns and beams, or columns and trusses

_____ g. The space between two purlins in a roof or between two vertical members in a bridge truss

_____ h. The top or bottom members of a truss

_____ i. A unit of force working within a member expressed in pounds per square inch (PSI) acting on structural members due to various types of loads

_____ j. The main member of a truss running along its lower side between supports and usually carrying tension and bending

_____ k. The top and bottom projection or outstanding parts of a beam, channel, or girder

_____ l. A bar used in slip joints for expansion joints

13. Beam
14. Clear span
15. Cope
16. Girder
17. Joist
18. Steel member
19. Top chord
20. Truss
21. Web
22. Weld
23. Working line
24. Working point (WP)

_____ m. Main member of a truss running along its upper side supporting the decking and usually carrying combined compression and bending

_____ n. A framed structure consisting of straight members jointed to form a pattern of interconnecting triangles, usually made of wood or metal

_____ o. To cut out a part of the top or bottom flange of a beam or channel so that it may fit another

_____ p. A unit part of some larger structure

_____ q. A large structural member of concrete, steel, or wood used to support members over openings or from column to column

_____ r. A large horizontal support member designed to carry bending stress; span from beam to beam

_____ s. A high temperature process for fusing metal members together

_____ t. The edge point where dimensions are given

_____ u. That horizontal measurement between the inside faces of the two bearings or supports

_____ v. A smaller wood or steel floor member that typically spans between girders

_____ w. The portion of an I-beam, channel, or girder between the upper and lower flanges

_____ x. The line where locating dimensions are given

25. Bent
26. Bolt
27. Column
28. Concrete
29. Grout
30. Gusset plate
31. Mark number
32. Nominal span
33. Pin
34. Prestressed concrete
35. Purlin

_____ y. A mixture of portland cement, fine aggregate, coarse aggregate, and water

_____ z. The horizontal members spanning from truss to truss, upon which the roof is carried

_____ aa. A vertical framework, usually columns and beams supporting other members

_____ bb. A vertical compression member, usually supporting beams and girders, attached to a footing; made of steel, wood, or concrete

_____ cc. Concrete that is precast or cast in place that has wires or cables that are stretched before the concrete is placed around them; the releasing of the wires or cables sets up internal stresses that counteract the external stresses of the applied load to prevent cracking and sagging

_____ dd. A fluid mixture of cement, water, and sand which can be poured to fill small voids or to smooth or level a surface of a wall or footing

_____ ee. A large diameter steel shaft connector similar to a bolt

_____ ff. A plate connecting the several members of a truss or other structural framework

_____ gg. A two-piece threaded fastener

_____ hh. Horizontal distance between the outside edges of supports

_____ ii. A system of numbering precast concrete structural members for tracking on a job

Objective 2

Define structural drawing.

____

____

Objective 3

List five types of structures.

a. ____

b. ____

c. ____

d. ____

e. ____

Written Test

Objective 4

List the four types of materials used for structures.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

Objective 5

List the three types of rolled steel products.

a. ______________________________

b. ______________________________

c. ______________________________

Objective 6

Match types of steel members below with their characteristics and descriptions.

1. Beams
2. Girders
3. Columns
4. Roof trusses
5. Bridge trusses

_____ a. Form the principal vertical supports of all steel structures other than bridges and similar spans which rest directly upon masonry and concrete

_____ b. Are used wherever a comparatively large area is to be covered without intermediate columns

_____ c. Generally are composed of a single piece

_____ d. Are beams made of more than one piece

_____ e. Are usually made with a web plate and flanges composed of angles, plates, or both, used to resist bending due to transverse loads

_____ f. For the through type, the floor load is applied along the lower chord, and traffic flows through it

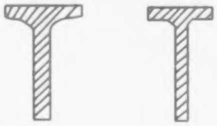
_____ g. Generally are placed horizontally and are subjected to vertical loads

_____ h. The web members are made of single or double angles with the longer legs vertical

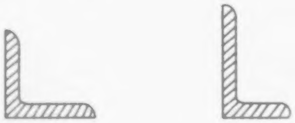
_____ i. On the deck type, the floor load is applied along the upper chord

Objective 7

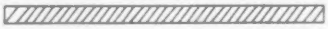
Identify the following structural steel shapes.



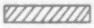
a. ______________________



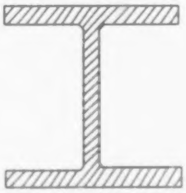
b. ______________________



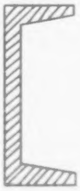
c. ______________________



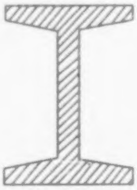
d. ______________________



e. ______________________



f. ______________________



g. ______________________

Objective 8

Select true statements about drawing practices for steel members by placing an "X" in the blanks next to the true statements.

_____ a. A scale of 1" = 1'0" is typically used for drawing large structures (framing and erection plans).

_____ b. No scale is used for most detail drawings (except on joints and trusses).

_____ c. Double line drawings are used when the scale doesn't allow for a lot of detail.

_____ d. The design drawing prepared by the designer/architect gives the structural detailer information to set up complete detail drawings.

_____ e. A legend is a key to the plan for identification of symbols and abbreviations used on the drawing.

_____ f. A shop bill is the document submitted to the engineering office for job payment.

Written Test

Objective 9

Select true statements concerning characteristics of shop drawings by placing an "X" in the blanks next to the correct characteristics.

_____ a. Shop drawings describe the type of construction and end loads.

_____ b. Detail drawings show length, size, and type and precise connection details

_____ c. All dimensions are given in a note format.

Objective 10

Describe the placement of gage lines for the following steel members.

a. Angles: ______________________________

b. Flange of a channel: ______________________________

c. Flange of an I-beam: ______________________________

Objective 11

Complete the following statements concerning fastener sizes and spacings by circling the correct words.

a. Minimum distance for fastener spacing along the gage line has been established by the **(AISC, ACI)**.

b. The minimum fastener size is governed by the following rule: The diameter of the fastener should never be **(less, more)** than the thickness of the metal punches.

Objective 12

Complete the following statements concerning dimensioning procedures for steel structures by circling the correct words.

a. Use **(unidirectional, aligned)** method for locating dimensions.

b. Dimensions are in feet and inches and should be placed **(in the middle, on top)** of the dimension line.

c. Longest and overall dimension should be **(closest to, farthest away from)** the view.

d. Dimensions should be placed no closer than **($^{5}/_{16}$″, $^{1}/_{2}$″)** apart and the first line should be no closer than double this distance.

e. Dimensions should be given to **(centerline, backs)** of beams.

f. Dimensions should be given to the top **(or, and)** bottom of beams and channels.

g. The slope of all members should be given in **(rise and run, angles)**.

Objective 13

Label the following structural steel callout.

W24 x 76
↑ ↑ ↑
a. b. c.

a. ____________________

b. ____________________

c. ____________________

Objective 14

Select true statements concerning structural steel marking procedures by placing an "X" in the blanks next to the true statements.

_____ a. Marks are used to provide a systematic procedure for detailing, fabricating, and erection.

_____ b. Each member of a structure is given a mark on the design layout.

_____ c. Mark is painted on the piece and used to erect the structure in the field.

_____ d. Every company uses the same system of marking.

Objective 15

List the steps a structural steel shape goes through in fabrication.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

Written Test

Objective 16

Match basic methods for fastening structural steel shapes with their definitions.

1. Welding
2. Bolting
3. Riveting

_____ a. Common fastening method used in the field

_____ b. Common method for connecting in the shop

_____ c. An old method of connecting structural members.

Objective 17

Match precast concrete abbreviations with their symbols.

Product Abbreviations

1. WP
2. BM
3. ST
4. CF
5. SqCol
6. COL
7. SqB
8. DT
9. RC
10. FS
11. RB
12. ITB
13. LT
14. LB

_____ a. Beam

_____ b. Core floor

_____ c. Column

_____ d. Double tee

_____ e. Flat slab

_____ f. Inverted tee beam

_____ g. L beam or ledger beam

_____ h. Lin tee

_____ i. Rectangular beam

_____ j. Rectangular column

_____ k. Square beam

_____ l. Square column

_____ m. Single tee

_____ n. Wall panel

Miscellaneous Abbreviations and Symbols

15. wp
16. b
17. wa
18. bp
19. tr
20. cb
21. hp
22. cp
23. ab
24. #8
25. #6
26. #7
27. #5
28. #3
29. #4

_____ o. Anchor bolt

_____ p. Blockout

_____ q. Baseplate or bearing pad

_____ r. Connection bolt

_____ s. Connection plate

_____ t. Heel plate

_____ u. Threaded rod

_____ v. Weld angle

_____ w. Weld plate

_____ x. 3/8″ Ø Reinforcing bar (#301, 302, 303, etc.)

_____ y. 4/8″ Ø Reinforcing bar (#401, 402, 403, etc.)

_____ z. 5/8″ Ø Reinforcing bar (#501, 502, 503, etc.)

_____ aa. 6/8″ Ø Reinforcing bar (#601, 602, 603, etc.)

_____ bb. 7/8″ Ø Reinforcing bar (#701, 702, 703, etc.)

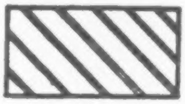
_____ cc. 8/8″ Ø Reinforcing bar (#801, 802, 803, etc.)

Written Test

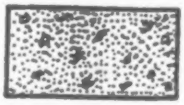
Objective 18

Identify types of sectional cross section symbols for precast concrete.

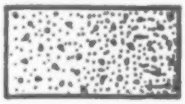
1. Rigid insulation
2. Plywood
3. Face brick
4. Cinder
5. Concrete
6. Common brick
7. Dimensional lumber
8. Batt insulation
9. Steel
10. Block
11. Finish board
12. Fire brick



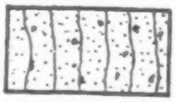
a. ______________



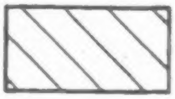
b. ______________



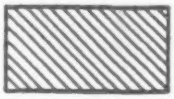
c. ______________



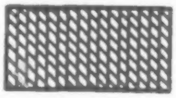
d. ______________



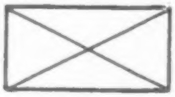
e. ______________



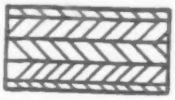
f. ______________



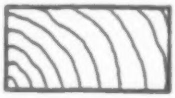
g. ______________



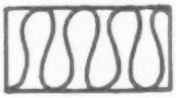
h. ______________



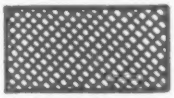
i. ______________



j. ______________



k. ______________



l. ______________

Objective 19

Complete statements concerning anchor bolts by filling in the blanks with the correct words.

a. Anchor bolts are used for ______________ ______________ to concrete foundations.

b. One type of anchor bolt is the ______________.

c. An alternative to drawing is to call out anchor bolts by diameter size, ______________, type, and bend dimension if needed.

d. Anchor bolt projects above top of grout a dimension equal to the sum of the following:

   1) ______________________

   2) Two anchor bolt diameters for two nuts

   3) One anchor bolt diameter

Objective 20

Distinguish between the types of concrete by placing an "X" next to the description of reinforced concrete.

_____ a. Has no mesh or rebars; used for places where only compression stresses occur

_____ b. Has mesh or steel rebar to help transmit the stresses of compression, tension, and shear forces

Objective 21

Complete the following statements concerning the types of concrete reinforcement by circling the correct words.

a. Reinforcing bar (rebar) is identified by number which indicates size in **(quarters, eighths)** of an inch.

b. Rebar sizes range from #2 to **(#6, #11)**.

c. All rebar is deformed except **(#2, #6)** which is round bar.

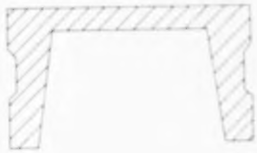
d. Rebar is made from **(cast iron, steel)** in lengths of 60 feet.

e. Wire mesh (welded wire fabric) is used as reinforcement in **(concrete slabs, steel columns)**.

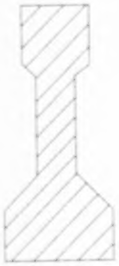
f. Welded wire fabric (WWF) is designated by wire spacing and **(type of wire, wire gage)**.

Objective 22

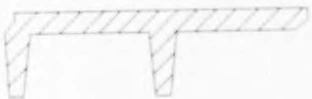
Identify the following standard prestressed concrete units.



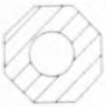
a. ______________________



b. ______________________

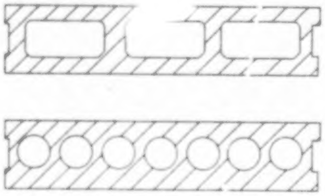


c. ______________________

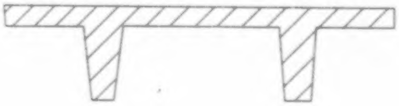


d. ______________________

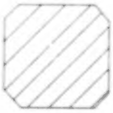
Written Test



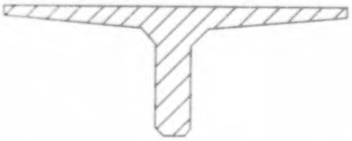
e. ______________________



f. ______________________



g. ______________________



h. ______________________

Objective 23

Match foundation parts with their descriptions.

1. Bell-bottomed footing
2. Foundation (stem) wall
3. Grade beam
4. Pedestal
5. Pier
6. Pilaster
7. Pilings
8. Spread footing (footer)

_____ a. Rests on the footing and used to support equipment such as pumps; usually stops one foot above grade line

_____ b. Placed under the pedestal or foundation wall and serves as a bearing member on soil

_____ c. Generally round 12″ to 16″ diameter concrete columns poured into drilled (augured) holes in the earth to solid bearing rock when expansive type (clay) soils are encountered

_____ d. Reinforced concrete beam that spans horizontally between piers for support of foundation wall; it replaces the spread footing in expansive soils

_____ e. Used in soil where soil bearing is poor and footing is at a great depth, which increases the bearing area on the soils

_____ f. Used for support of wood framed walls and edge slab support as a method to distribute those loads to a spread footing or grade beam

_____ g. Precast, tapered, reinforced concrete shafts driven into the earth to provide support when mass of structure exceeds limits of soil bearing; usually high-rise structures require their use

_____ h. Rectangular-shaped protrusions from masonry walls to provide additional lateral wall support especially where beams intersect the wall

Objective 24

Match types of structural drawings for concrete with their descriptions.

1. Engineering drawing
2. Placing drawing
3. Preprinted drawing

_____ a. Used for standard details. Drafter needs only to add dimensions, bolt quantity and size, and assign rebar mark numbers and size

_____ b. Shows where concrete dimensions are, but rebar details are omitted

_____ c. Shows the foundation outline without the outline dimensions, but shows all rebar locations and dimensions (used by fabricators and in the field) and bar lists, schedules, and bending details

Objective 25

Complete the following chart of standard symbols and abbreviations for concrete placing drawings.

SYMBOLS		ABBREVIATIONS	
_____	To indicate size of deformed bar	Bt	_____
_____	Plain rounds, as spirals	T	_____
_____	Spacing center to center	_____	Each face
⇋	_____	Str	_____
↔	_____	NF	_____

Objective 26

Select true statements concerning standard practices for documentation of rebar by placing an "X" in the blanks next to the true statements.

_____ a. Rebar is dimensioned as cut to cut and the bar length is the sum of all detailed dimensions.

_____ b. Rebars should never be bent.

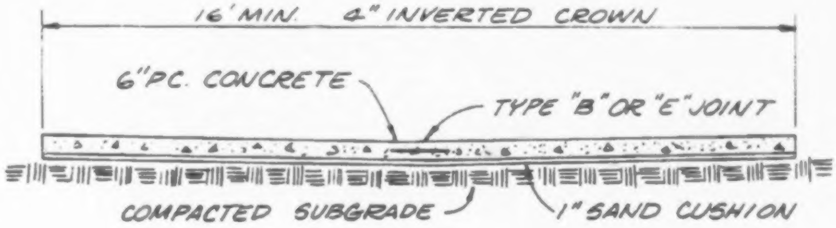
_____ c. Dimensions are to the centerlines of rebars.

_____ d. Rebar schedules give total lengths of bars required and show sizes, lengths, and weights of all rebars.

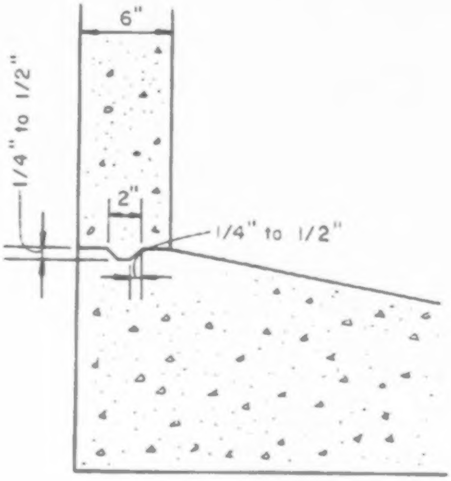
Written Test

Objective 27

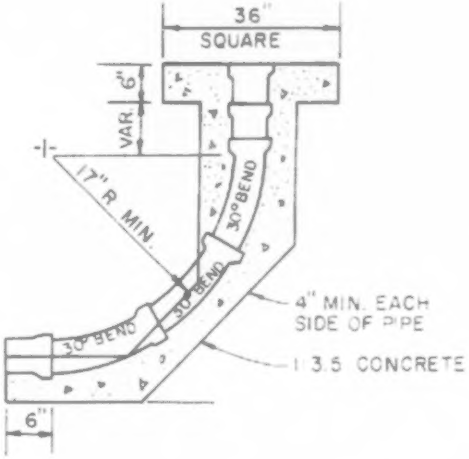
Identify the following examples of typical details for concrete structures.


16' MIN. 4" INVERTED CROWN
6" PC. CONCRETE
TYPE "B" OR "E" JOINT
COMPACTED SUBGRADE
1" SAND CUSHION

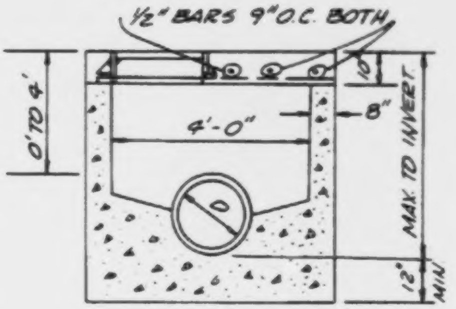
a. ______________________________


6"
1/4" to 1/2"
2"
1/4" to 1/2"

b. ______________________________


36"
SQUARE
6"
VAR.
17" R MIN.
30° BEND
30° BEND
30° BEND
4" MIN. EACH SIDE OF PIPE
1:3.5 CONCRETE
6"

c. ______________________________



d. ______________________________

Objective 28

Complete the following statements concerning wood construction by circling the correct words.

a. **(Frame, Timber)** is lumber 5 inches or larger in the least dimension generally used for heavy wood members or construction.

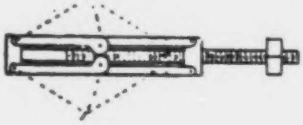
b. **(Timber, Lumber)** is the product of the saw and planing mill.

c. **(Frame, Timber)** is usually applied to light wood construction.

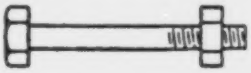
d. Lumber dimensions are called out in **(actual, nominal)** size.

Objective 29

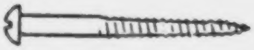
Identify the following types of wood connectors.



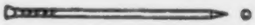
a. ______________________________



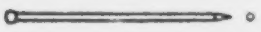
b. ______________________________



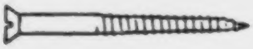
c. ______________________________



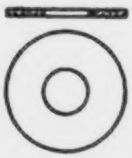
d. ______________________________



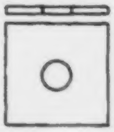
e. ______________________________



f. ______________________________



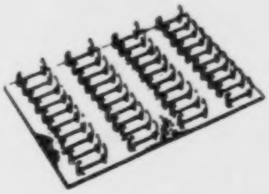
g. ______________________________



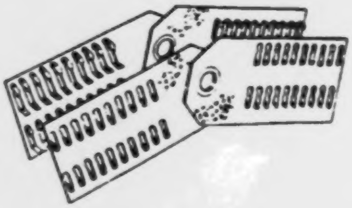
h. ______________________________

Objective 30

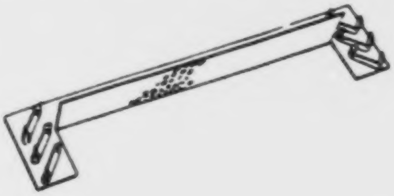
Identify the following types of framing connectors.



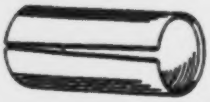
a. ______________________



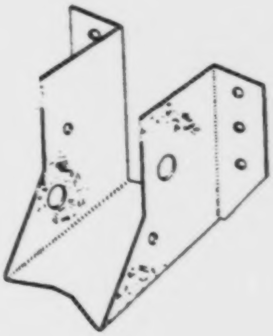
b. ______________________



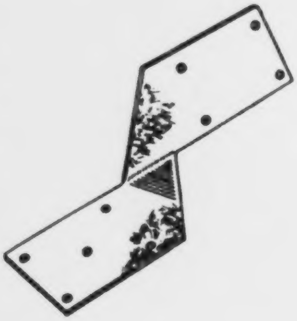
c. ______________________



d. ______________________



e. ______________________



f. ______________________

Objective 31

Select true statements concerning components of wood construction by placing an "X" in the blanks next to the true statements.

_____ a. Wood columns are square timbers rarely smaller than 12 x 12 inches and not larger than 3 x 3 feet.

_____ b. Wood studs are used for dwellings to carry light loads and receive support from the material attached to them.

_____ c. In wood frame construction the common depths for rafters are 8 to 12 inches.

_____ d. In wood frame construction the common depths for joists are 4 to 6 inches.

_____ e. For heavy timber the minimum thickness permitted for joists, beams, girders, and other members is 6" and minimum depth is 10".

_____ f. Wood trusses are used to support roofs or floors.

Objective 32

Complete the following statements concerning heavy timber construction by correctly filling in the blanks.

a. Exterior walls are masonry or other noncombustible materials with a fire resistance rating of at least ______________________ hours.

b. Floors and roofs are ______________________.

c. Member sizes are determined by the ______________________.

d. Interior girders are supported by ______________________

e. Traverse beams span the distance between lines of girders and are supported by ______________________.

f. A tongue-and-groove or a laminated deck may span the space between ______________________.

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 10
b. 7
c. 4
d. 6
e. 9
f. 1
g. 8
h. 3
i. 12
j. 2
k. 5
l. 11
m. 19
n. 20
o. 15
p. 18
q. 13
r. 16
s. 22
t. 24
u. 14
v. 17
w. 21
x. 23
y. 28
z. 35
aa. 25
bb. 27
cc. 34
dd. 29
ee. 33
ff. 30
gg. 26
hh. 32
ii. 31

Objective 2

Structural drawing—All layout and detail drawings connected with the design and construction of buildings, bridges, viaducts and similar structures in which structural steel, timber, concrete, and other building materials are used

Objective 3

Any five of the following:

a. Buildings
b. Bridges
c. Dams
d. Reinforced concrete foundations
e. Manholes
f. Box culverts
g. Retaining walls
h. Power transmission tower
i. Signs

Objective 4

a. Steel
b. Concrete
c. Timber
d. Aluminum

Objective 5

a. Plate
b. Bars
c. Shapes

Objective 6

a. 3
b. 4
c. 1
d. 2
e. 2
f. 5
g. 1
h. 4
i. 5

Answers to Written Test

Objective 7	a. Structural tees b. Angles c. Plate d. Flat bar e. Wide flange shape f. Channel g. Beam
Objective 8	b, d, e
Objective 9	a, b
Objective 10	a. Angles—Gage line is measured from the back of the angle b. Flange of a channel—Gage line is measured from the back of the channel c. Flange of an I-beam—Gage line is measured from the center
Objective 11	a. AISC b. Less
Objective 12	a. Aligned b. On top c. Farthest away from d. 5/16" e. Centerline f. Or g. Rise and run
Objective 13	a. Shape b. Depth c. Weight
Objective 14	a, b, c
Objective 15	a. Handling and cutting b. Punching and drilling c. Straightening d. Bending e. Bolting f. Riveting g. Welding h. Finishing
Objective 16	a. 2 b. 1 c. 3

Answers to Written Test

Objective 17

a. 2
b. 4
c. 6
d. 8
e. 10
f. 12
g. 14
h. 13
i. 11
j. 9
k. 7
l. 5
m. 3
n. 1
o. 23
p. 16
q. 18
r. 20
s. 22
t. 21
u. 19
v. 17
w. 15
x. 28
y. 29
z. 27
aa. 25
bb. 26
cc. 24

Objective 18

a. 9
b. 5
c. 4
d. 10
e. 6
f. 3
g. 12
h. 7
i. 2
j. 11
k. 8
l. 1

Objective 19

a. fastening structural members
b. Any one of the following:
   1) J-bolt
   2) machine bolt
   3) cane head anchor bolt (CHAB)
c. length
d. Equipment base thickness

Objective 20

b

Objective 21

a. Eighths
b. #11
c. 2
d. Steel
e. Concrete slabs
f. Wire gage

Objective 22

a. Channel slab
b. Girder (I)
c. Mono-wing (F) section
d. Piles
e. Hollow core slabs
f. Double tee
g. Column
h. Single tee

Objective 23

a. 4
b. 8
c. 5
d. 3
e. 1
f. 2
g. 7
h. 6

Objective 24

a. 3
b. 1
c. 2

Answers to Written Test

Objective 25

SYMBOLS		ABBREVIATIONS	
#	To indicate size of deformed bar	Bt	Bent
ϕ	Plain rounds, as spirals	T	Top
@	Spacing center to center	EF	Each face
⇆	Direction in which bars extend	Str	Straight
↔	Limits of area covered by bars	NF	Near face

Objective 26

a, d

Objective 27

a. Highway structure
b. Wall and floor joint
c. Underground structure—Clean-out
d. Underground structure—Manhole

Objective 28

a. Timber
b. Lumber
c. Frame
d. Nominal

Objective 29

a. Toggle bolt
b. Machine bolt
c. Round head screw
d. Casing nail
e. Finishing nail
f. Flat head screw
g. Circular flat washer
h. Plate washer

Objective 30

a. Connector
b. Hinge plate
c. Web
d. Romex
e. Hanger
f. Framing anchor

Objective 31

b, e, f

Objective 32

a. two
b. heavy plank or laminated wood
c. length of span
d. wood columns, pipe, or steel structural shapes
e. metal hangers
f. beams

Prerequisites: Units 1 through 7

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 and 2 to familiarize yourself with common terms used in structural drafting.

☐ 4. **Study** Information Sheet, Objectives 3 through 7, and Student Supplement 1.

☐ 5. **Study** Information Sheet, Objectives 8 through 11, and Student Supplement 2.

☐ 6. **Study** Information Sheet, Objective 12, and Student Supplements 3 and 4.

☐ 7. **Study** Information Sheet, Objectives 13 through 16.

CAD ☐ 8. **Do** Assignment Sheet 1, "Prepare Detail Drawings of Structural Steel Members."

☐ 9. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 8 and 9.

☐ 10. **Study** Information Sheet, Objectives 17 through 27 and Student Supplements 5 and 6.

CAD ☐ 11. **Do** Assignment Sheet 2, "Draw to Scale a Concrete Engineering Drawing."

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Learning Activities Sheet

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 11 and 12.

☐ 13. **Study** Information Sheet, Objectives 28 through 32, and Student Supplement 7.

CAD

☐ 14. **Do** Assignment Sheet 3, "Detail a Wood Truss."

☐ 15. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 14 and 15.

☐ 16. **Check** With instructor for any additional assignments to be completed.

☐ 17. **Do** Additional assignments listed below.

____

____

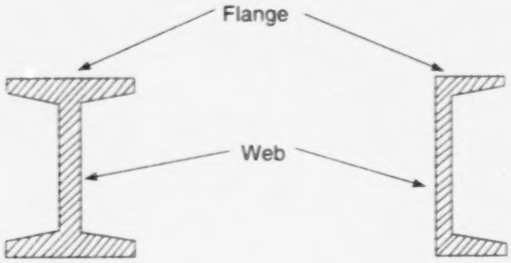
____

☐ 18. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 19. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

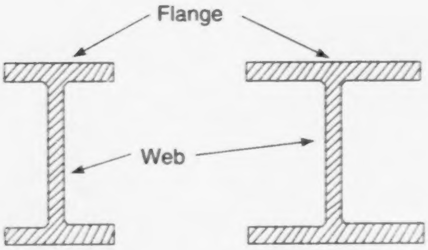
***Permission to duplicate this form is granted.**

Structural Steel Designations



American Standard Beam

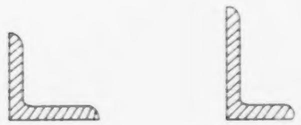
American Standard Channel



W Beam

W Column

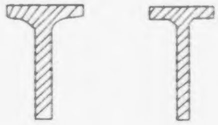
Wide Flange Shapes



Equal Legs

Unequal Legs

Angle Shapes (L)



ST

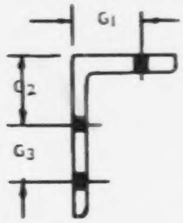
WT

Structural Tees

Plate (PL)

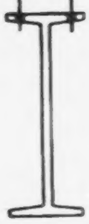
Flat Bar (Bar)

Gage Line Standards



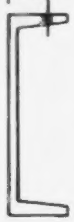
GAGE	LEG SIZE (Inches)										
	8	6	5	4	3 1/2	3	2 1/2	2	1 3/4	1 3/8	1
G1	4 1/2	3 1/2	3 1/8	2 1/2	2 3/8	1 3/4	1 3/8	1 3/16	1	7/8	5/8
G2	3 1/8	2 3/8	1 3/4								
G3	3 1/8	2 1/2	2								

FLANGE WIDTH	G
2 3/8 to 2 3/4	1 1/2
3 to 3 3/8	1 3/4
3 1/2 to 4	2
4 to 4 3/4	2 1/8
5 to 5 3/4	3
6 to 7 1/4	3 3/4
7 1/2 to 8	5



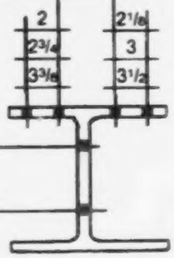
S Shapes

FLANGE WIDTH	G
1 3/8 to 1 1/2	3/4
1 3/4	1
1 3/4 to 2	1 3/16
2 1/8	1 3/16
2 1/8 to 2 3/8	1 3/8
2 1/2 to 2 3/4	1 1/2
2 7/8 to 3 1/8	1 3/4
3 3/8 to 3 5/8	2 1/8
3 3/4 to 4 3/8	2 1/2



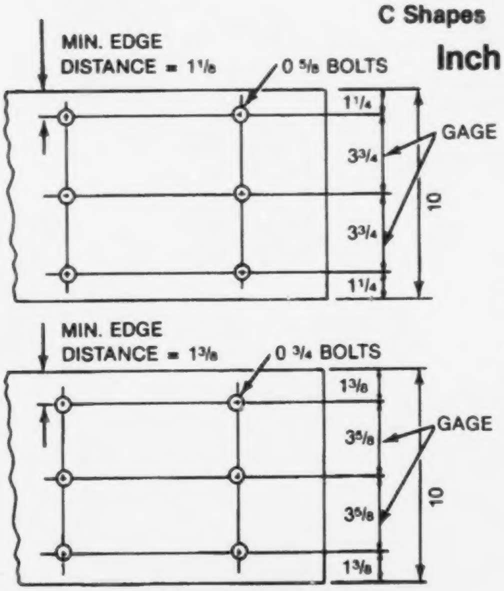
C Shapes

FLANGE WIDTH	G
4	2 1/8
5 to 5 3/4	3
6 to 7 1/8	3 3/4
7 1/2 and Up	5 1/8


2
2 3/4
3 3/8
2 1/8
3
3 1/2

DEPTH OF W AND M COLUMN	G
6	2 1/8
8	3 3/4
10 to 14	5

Inch Sizes


MIN. EDGE
DISTANCE = 1 1/8
0 5/8 BOLTS
1 1/4
3 3/4
GAGE
3 3/4
1 1/4
10
MIN. EDGE
DISTANCE = 1 3/8
0 3/4 BOLTS
1 3/8
3 5/8
GAGE
3 5/8
1 3/8
10

Establishing Gage Sizes from Edge Distance

	Bolt Diameter	At Sheared Edge	At Rolled or Gas Cut Edge
U.S. Customary (Inches)	1/2	1	3/4
	5/8	1 1/8	7/8
	3/4	1 3/8	1
	7/8	1 1/2	1 1/8
	1	1 5/8	1 3/16
	1 1/8	1 3/4	1 3/8
	1 1/4	2	1 1/2
	1 3/8	2 1/2	1 13/16

Minimum Edge Distance for Bolt

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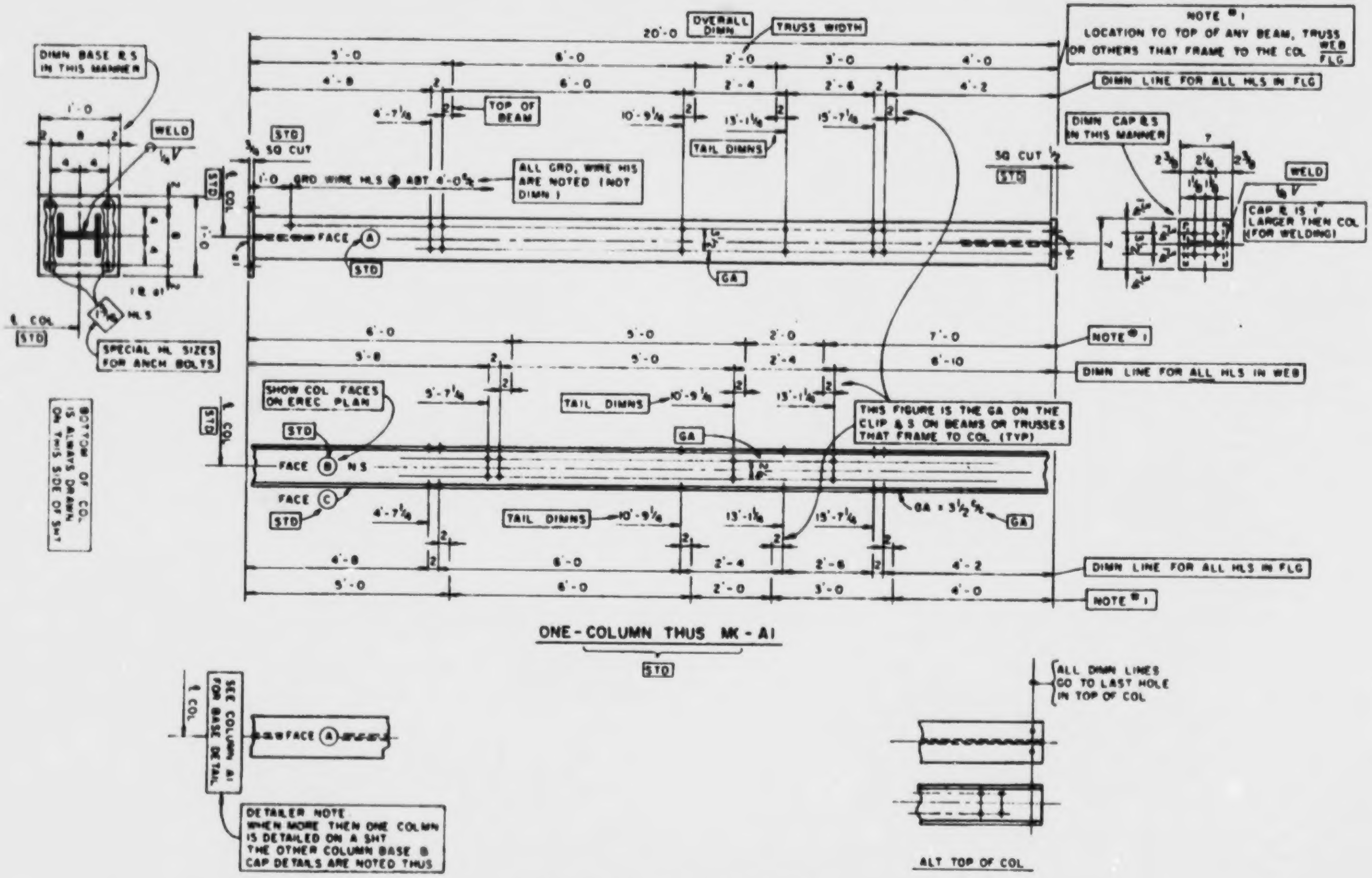
Dimensioning Procedures for Structural Steel


20'-0
OVERALL DIMN
TRUSS WIDTH
NOTE # 1
LOCATION TO TOP OF ANY BEAM, TRUSS OR OTHERS THAT FRAME TO THE COL WEB/FLG
DIMN LINE FOR ALL HLS IN FLG
DIMN BASE R.S IN THIS MANNER
WELD
TOP OF BEAM
TAIL DIMNS
STD
SQ CUT
ALL GRD, WIRE HLS ARE NOTED (NOT DIMN)
GRD WIRE HLS @ ABT 4'-0
DIMN CAP R.S IN THIS MANNER
CAP R IS 1" LARGER THEN COL (FOR WELDING)
FACE A
GA
℄ COL
SPECIAL HL SIZES FOR ANCH BOLTS
NOTE # 1
DIMN LINE FOR ALL HLS IN WEB
SHOW COL FACES ON EREC PLAN
THIS FIGURE IS THE GA ON THE CLIP & S ON BEAMS OR TRUSSES THAT FRAME TO COL (TYP)
BOTTOM OF COL IS ALWAYS DRAWN ON THIS SIDE OF SHT
FACE B
N S
FACE C
GA = 3½
DIMN LINE FOR ALL HLS IN FLG
NOTE # 1
ONE - COLUMN THUS MK - A1
SEE COLUMN A1 FOR BASE DETAIL
DETAILER NOTE WHEN MORE THEN ONE COLMN IS DETAILED ON A SHT THE OTHER COLUMN BASE & CAP DETAILS ARE NOTED THUS
ALL DIMN LINES GO TO LAST HOLE IN TOP OF COL
ALT TOP OF COL

Courtesy of Public Service Company of Oklahoma

STANDARD METHOD FOR DETAILING
WF OR B SERIES COLUMNS

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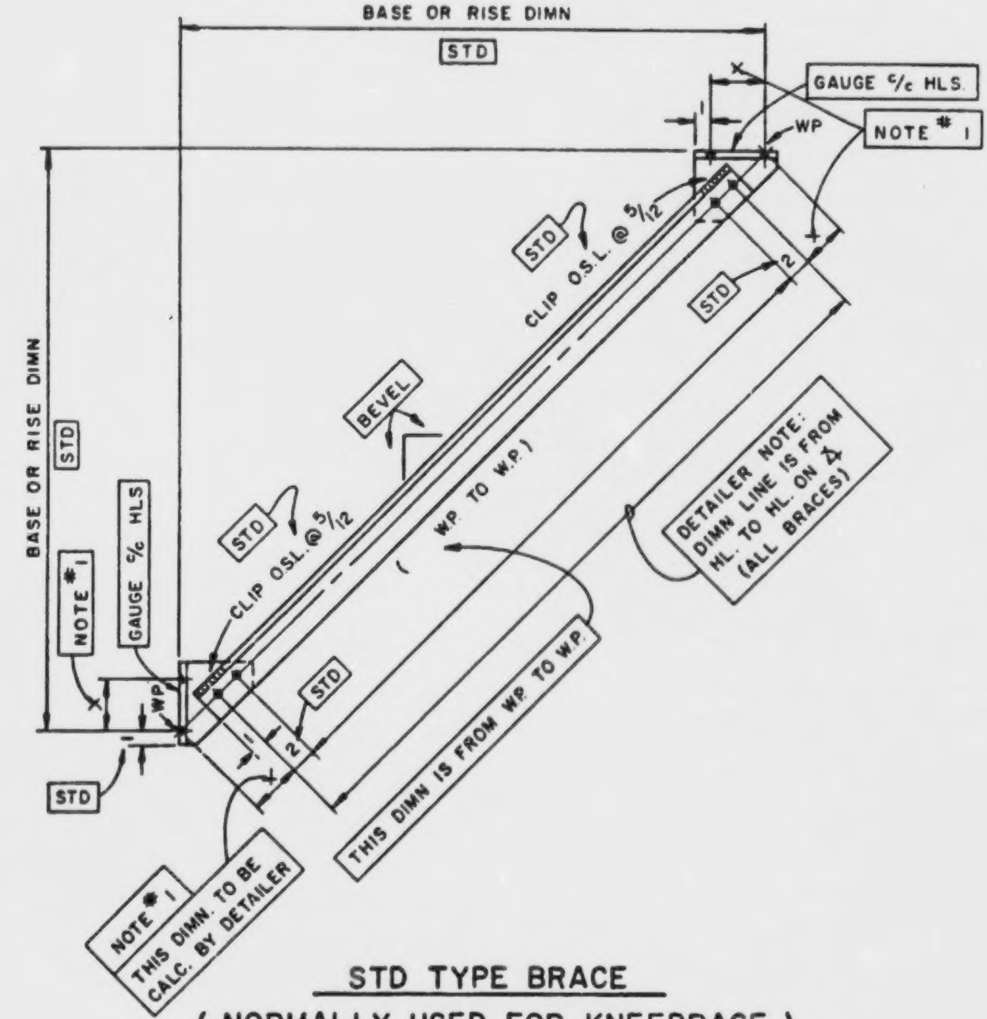
Dimensioning Procedures for Structural Steel

(continued)


BASE OR RISE DIMN
STD
GAUGE c/c HLS.
NOTE # 1
WP
x
1
STD
CLIP O.S.L. @ 5/12
2
STD
BEVEL
W.P. TO W.P.
DETAILER NOTE: DIMN LINE IS FROM HL. TO HL. ON ℄ (ALL BRACES)
BASE OR RISE DIMN
STD
NOTE # 1
GAUGE c/c HLS
STD
CLIP O.S.L. @ 5/12
WP
STD
2
x
STD
THIS DIMN IS FROM W.P. TO W.P.
NOTE # 1
THIS DIMN. TO BE CALC. BY DETAILER

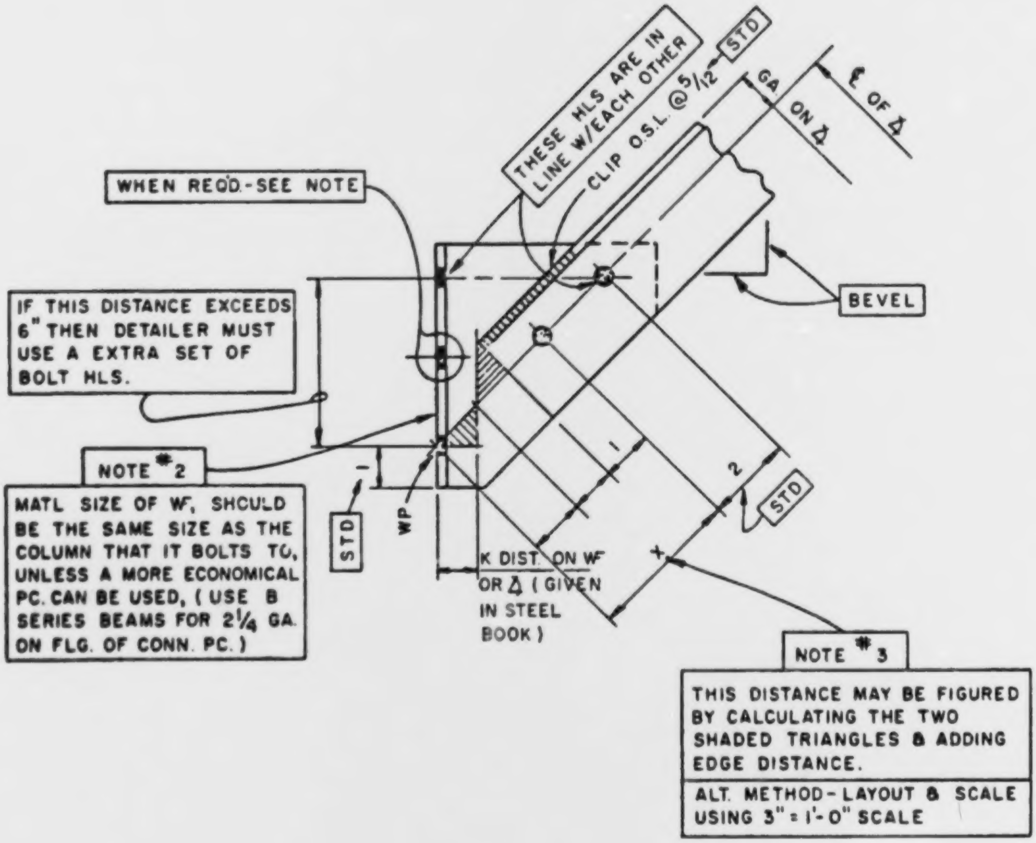
STD TYPE BRACE

(NORMALLY USED FOR KNEEBRACE)

Courtesy of Public Service Company of Oklahoma

Dimensioning Procedures for Structural Steel

(continued)



THESE HLS ARE IN LINE W/EACH OTHER
CLIP O.S.L. @ 5/12
STD
GA ON ∠
℄ OF ∠
WHEN REQ'D.-SEE NOTE
BEVEL
WP
STD
1
2
STD
X
K DIST. ON WF OR ∠ (GIVEN IN STEEL BOOK)

IF THIS DISTANCE EXCEEDS 6" THEN DETAILER MUST USE A EXTRA SET OF BOLT HLS.

NOTE #2

MATL SIZE OF WF, SHOULD BE THE SAME SIZE AS THE COLUMN THAT IT BOLTS TO, UNLESS A MORE ECONOMICAL PC. CAN BE USED, (USE B SERIES BEAMS FOR 2¼ GA. ON FLG. OF CONN. PC.)

NOTE #3

THIS DISTANCE MAY BE FIGURED BY CALCULATING THE TWO SHADED TRIANGLES & ADDING EDGE DISTANCE.

ALT. METHOD - LAYOUT & SCALE USING 3" = 1'-0" SCALE

DETAIL NO. 1

THE ABOVE METHOD SHOWS HOW TO CALCULATE THE DIMN FOR THE CONNECTING PC. OF A BRACE. THE CONNECTING PC. MAY BE AN ANGLE OR WF (USE WF WHERE POSSIBLE.) BUT BOTH CAN BE FIGURED THE SAME WAY.

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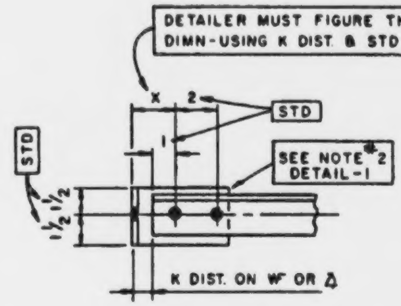
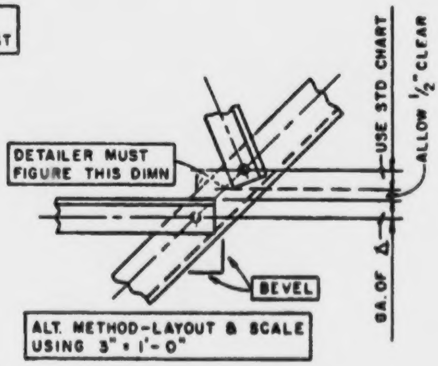
Dimensioning Procedures for Structural Steel

(continued)

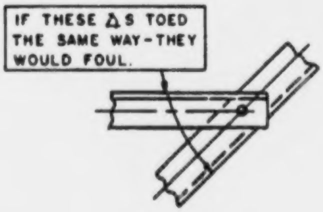
DRAFTING REFERENCE MANUAL


DETAILER MUST FIGURE THIS DIMN-USING K DIST. & STD EDGE DIST
X
2
1
STD
STD
SEE NOTE #2 DETAIL-1
1½
1½
K DIST. ON W OR ∆

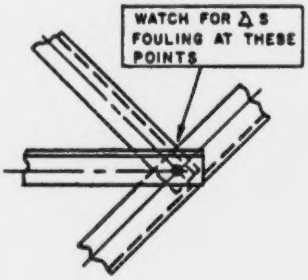
DETAIL NO. 2


DETAILER MUST FIGURE THIS DIMN
USE STD CHART
ALLOW ½" CLEAR
GA. OF ∆
BEVEL
ALT. METHOD-LAYOUT & SCALE USING 3" = 1'-0"

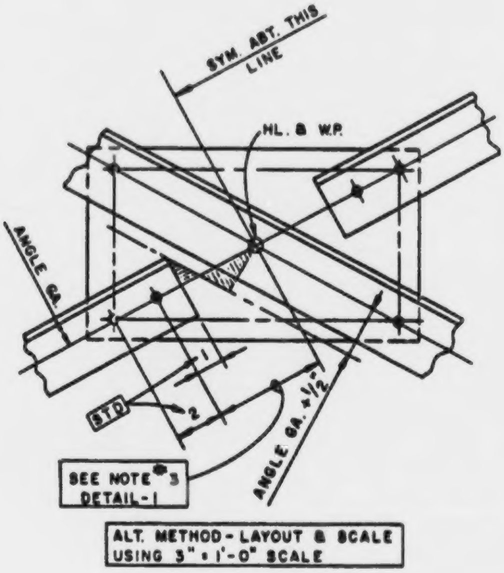
DETAIL NO. 3


IF THESE ∆S TOED THE SAME WAY-THEY WOULD FOUL.

DETAIL NO. 4


WATCH FOR ∆S FOULING AT THESE POINTS

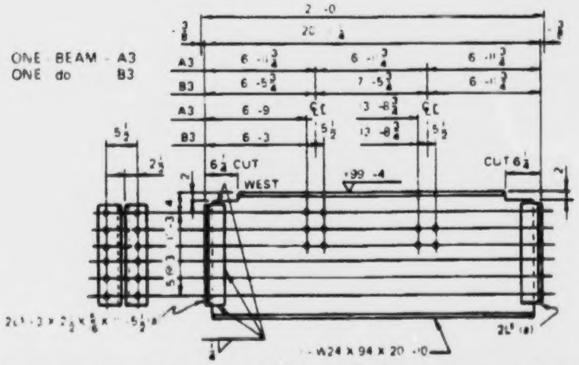
DETAIL NO. 5


SYM. ABT. THIS LINE
HL. & W.P.
ANGLE GA.
1
2
STD
ANGLE GA. +½
SEE NOTE #3 DETAIL-1
ALT. METHOD-LAYOUT & SCALE USING 3" = 1'-0" SCALE

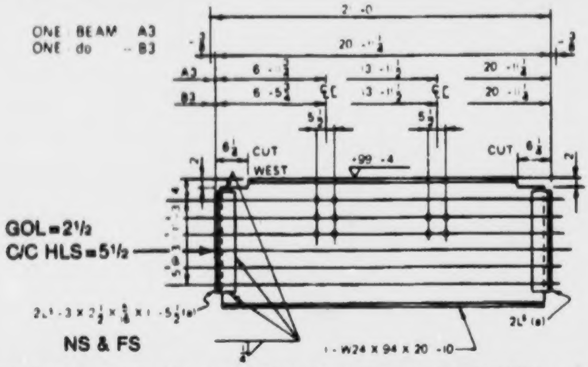
DETAIL NO. 6

Courtesy of Public Service Company of Oklahoma

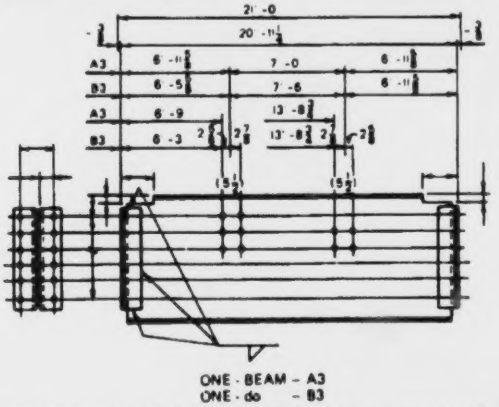
Dimensioning Beam Channels


ONE BEAM - A3
ONE do B3
A3
B3
6½ CUT
WEST
CUT 6½
2L⁵ (a)
1 - W24 x 94 x 20 -10

Dimensioning to Centerline of Channel Webs and Centerline of Holes from Left End of Beam


ONE BEAM A3
ONE do B3
A3
B3
6½ CUT
WEST
CUT 6½
GOL=2½
C/C HLS=5½
NS & FS
2L⁵ (a)
1 - W24 x 94 x 20 -10

Dimensioning from the Left End of Beam to Centerline of Channel Webs


A3
B3
ONE - BEAM - A3
ONE - do - B3

Dimensioning to Centerline of Holes with Reference to Backs of Channels

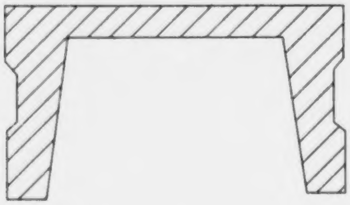
Courtesy of Public Service Company of Oklahoma

Rebar Data

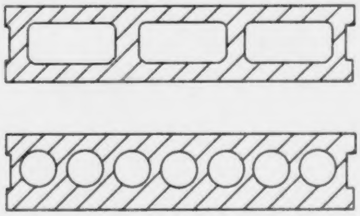
Standard ASTM A-305 Reinforcing Bars

Bar Size Number	Weight # Per Foot	Diameter Inches	Cross Sectional Area, Sq. Inches	Perimeter, Inches
2	0.167	0.250	0.05	0.786
3	0.376	0.375	0.11	1.178
4	0.668	0.500	0.20	1.571
5	1.043	0.625	0.31	1.963
6	1.502	0.750	0.44	2.356
7	2.044	0.875	0.60	2.749
8	2.670	1.000	0.79	3.142
9	3.400	1.128	1.00	3.544
10	4.303	1.270	1.27	3.990
11	5.313	1.410	1.56	4.430
Special ASTM A-408 Reinforcing Bars				
14S	7.65	1.693	2.25	5.32
18S	13.60	2.257	4.00	7.09

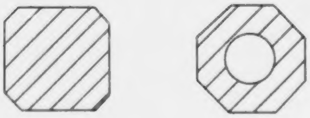
Standard Prestress Concrete Units



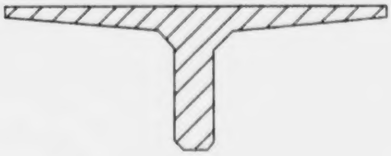
Channel Slab



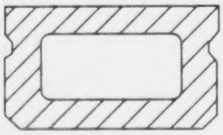
Hollow Core Slabs



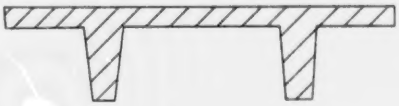
Columns and Piles



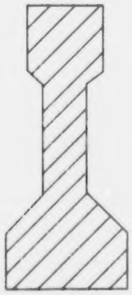
Single Tee



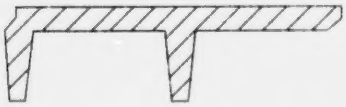
Box Girder



Double Tee



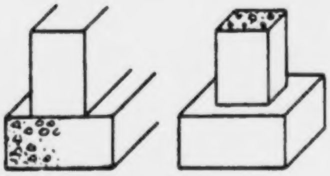
"I" Girder



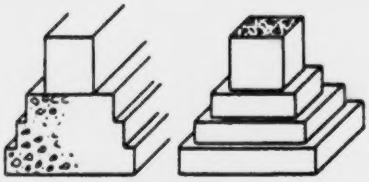
Mono-Wing ("F") Section

TM 9

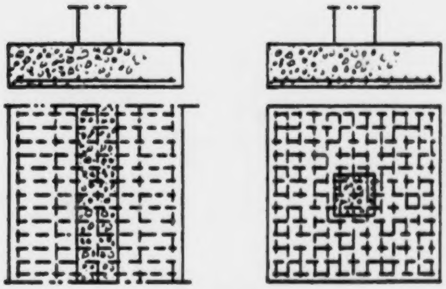
Examples of Foundation Parts



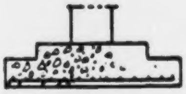
Simple Footings



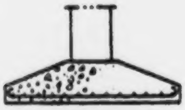
Plain Stepped Footings



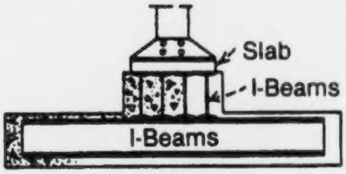
Slab Footings



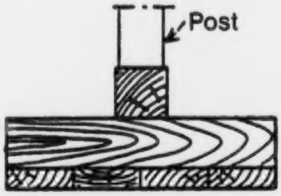
Stepped



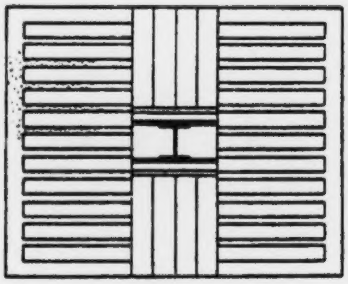
Sloped



Elevation



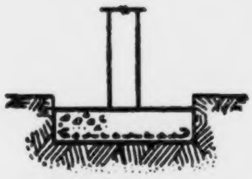
Timber Grillage Footing



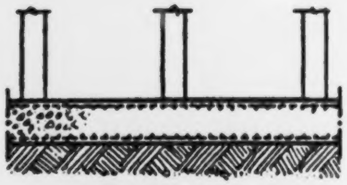
Plan

Steel Grillage Footing

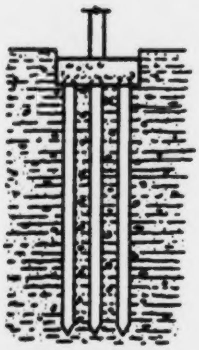
Examples of Foundation Parts
(continued)



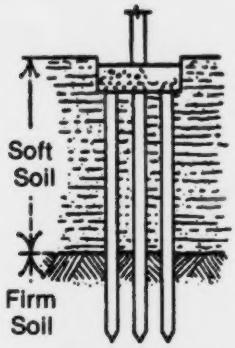
Reinforced Concrete Column Footing



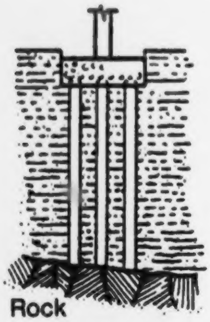
Reinforced Concrete Mat or Raft



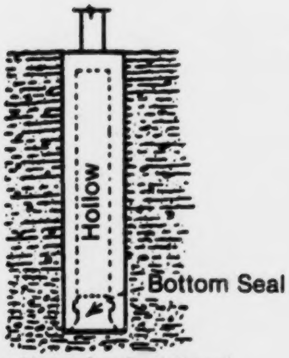
Piles in Soil


Soft Soil
Firm Soil

Piles through Soft Soil into Firm Soil

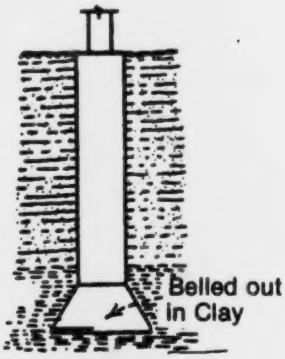


Piles Bearing on Rock

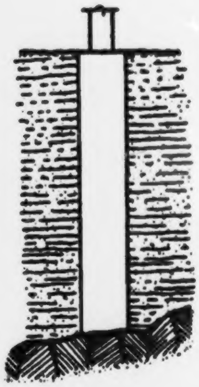

Hollow
Bottom Seal

(Not Used for Buildings)

Piers in Soil

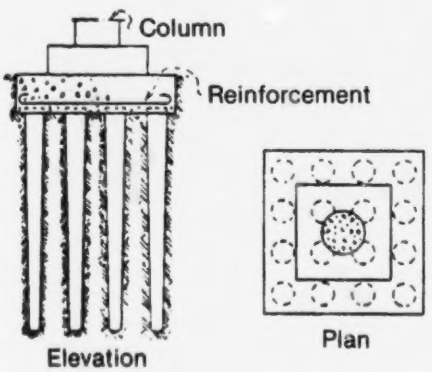

Belled out in Clay

Piers on Firm Clay or Hardpan



Piers on Rock

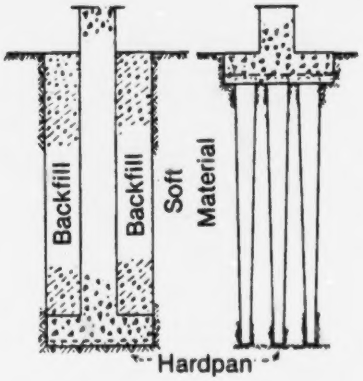
Examples of Foundation Parts
(continued)


Column
Reinforcement

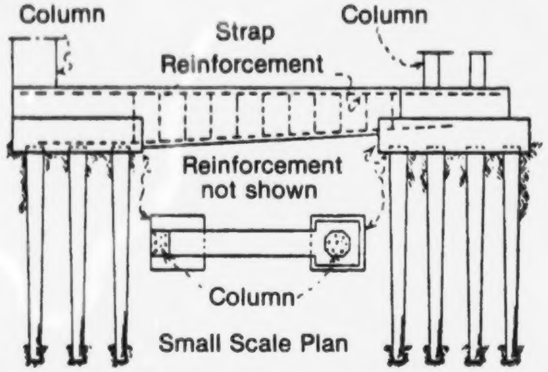
Elevation

Plan

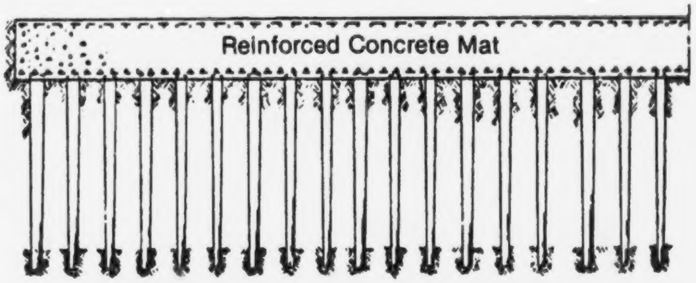
Footing on Piles


Backfill
Backfill
Soft Material
Hardpan

Use of Piles to Carry Footing

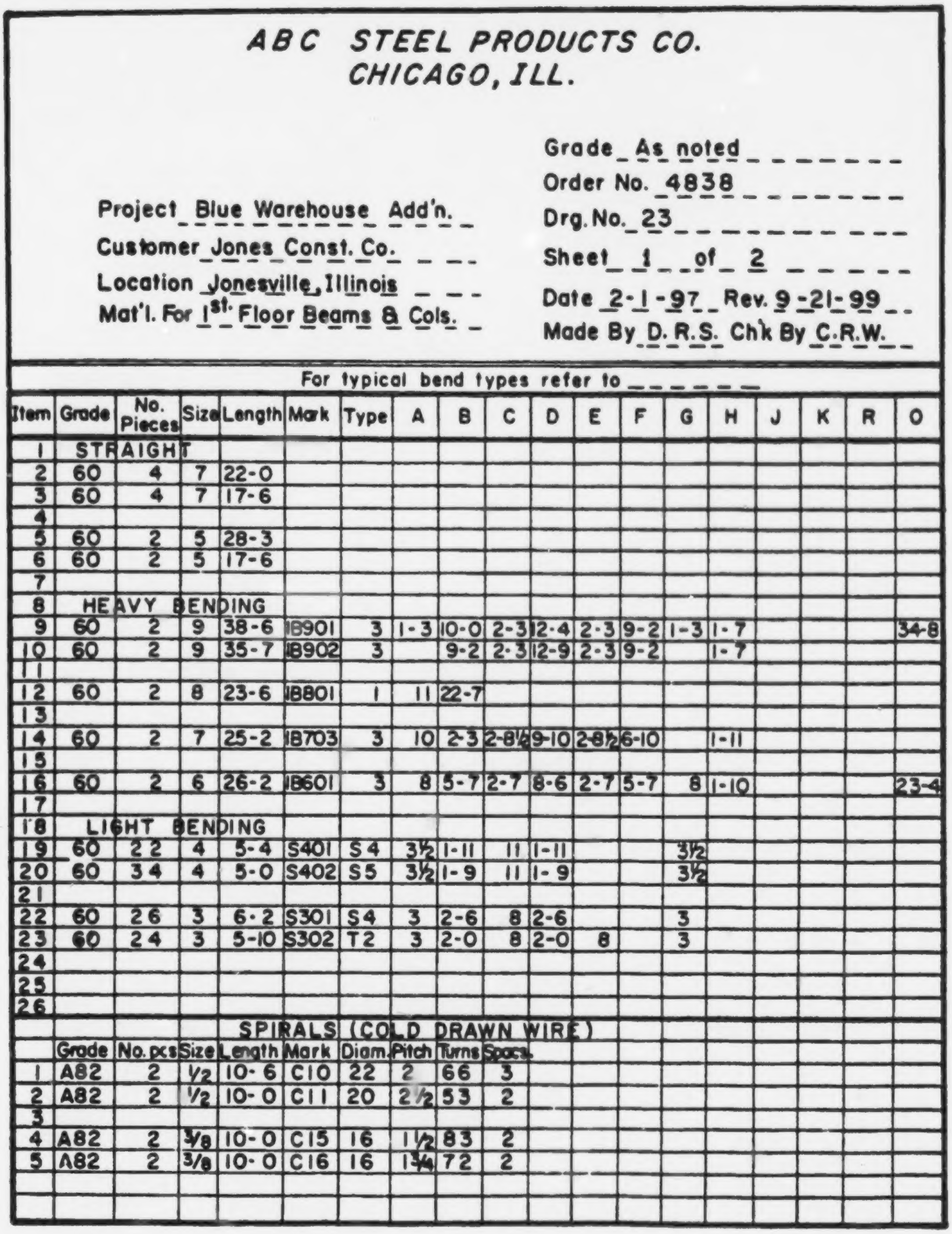

Column
Strap Reinforcement
Column
Reinforcement not shown
Column
Small Scale Plan

Reinforced Concrete Cantilever Footing on Piles


Reinforced Concrete Mat

Reinforced Concrete Mat Footing on Piles

Typical Bar List



ABC STEEL PRODUCTS CO.
CHICAGO, ILL.

Grade As noted
Order No. 4838
Project Blue Warehouse Add'n.
Drg. No. 23
Customer Jones Const. Co.
Sheet 1 of 2
Location Jonesville, Illinois
Date 2-1-97 Rev. 9-21-99
Mat'l. For 1st. Floor Beams & Cols.
Made By D. R. S. Ch'k By C.R.W.

For typical bend types refer to ______

Item	Grade	No. Pieces	Size	Length	Mark	Type	A	B	C	D	E	F	G	H	J	K	R	O
1	STRAIGHT																	
2	60	4	7	22-0														
3	60	4	7	17-6														
4																		
5	60	2	5	28-3														
6	60	2	5	17-6														
7																		
8	HEAVY BENDING																	
9	60	2	9	38-6	IB901	3	1-3	10-0	2-3	12-4	2-3	9-2	1-3	1-7				34-8
10	60	2	9	35-7	IB902	3		9-2	2-3	12-9	2-3	9-2		1-7				
11																		
12	60	2	8	23-6	IB801	1	11	22-7										
13																		
14	60	2	7	25-2	IB703	3	10	2-3	2-8½	9-10	2-8½	6-10		1-11				
15																		
16	60	2	6	26-2	IB601	3	8	5-7	2-7	8-6	2-7	5-7	8	1-10				23-4
17																		
18	LIGHT BENDING																	
19	60	22	4	5-4	S401	S4	3½	1-11	11	1-11			3½					
20	60	34	4	5-0	S402	S5	3½	1-9	11	1-9			3½					
21																		
22	60	26	3	6-2	S301	S4	3	2-6	8	2-6			3					
23	60	24	3	5-10	S302	T2	3	2-0	8	2-0	8		3					
24																		
25																		
26																		
					SPIRALS (COLD DRAWN WIRE)													
	Grade	No. pcs	Size	Length	Mark	Diam.	Pitch	Turns	Spacs.									
1	A82	2	½	10-6	C10	22	2	66	3									
2	A82	2	½	10-0	C11	20	2½	53	2									
3																		
4	A82	2	3/8	10-0	C15	16	1½	83	2									
5	A82	2	3/8	10-0	C16	16	1¾	72	2									

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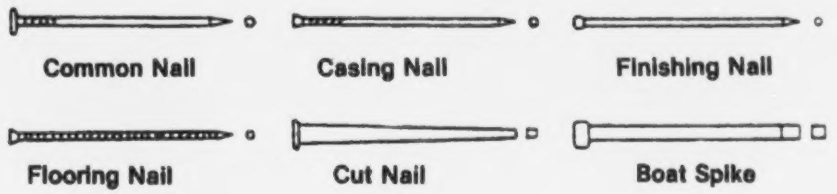
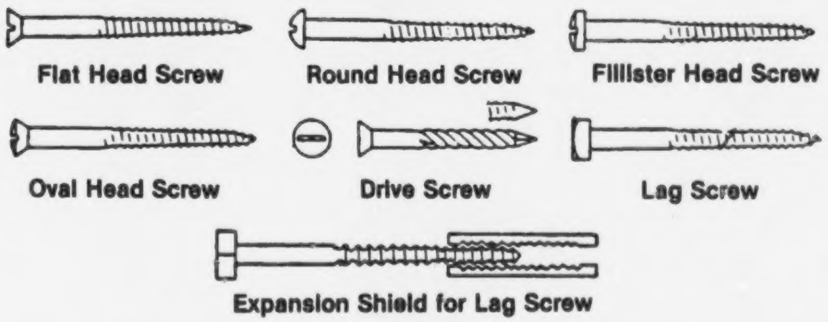
Common Wood Connectors



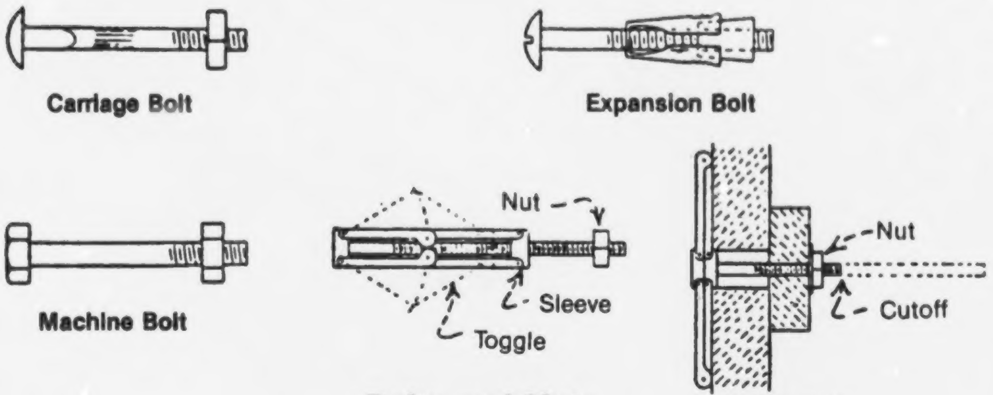
Common Nail
Casing Nail
Finishing Nail
Flooring Nail
Cut Nail
Boat Spike

Nails



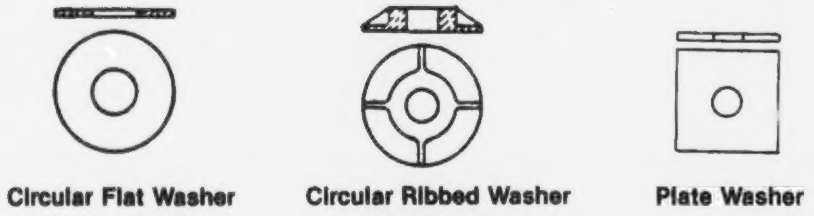
Flat Head Screw
Round Head Screw
Fillister Head Screw
Oval Head Screw
Drive Screw
Lag Screw
Expansion Shield for Lag Screw

Screws



Carriage Bolt
Expansion Bolt
Machine Bolt
Toggle Bolt

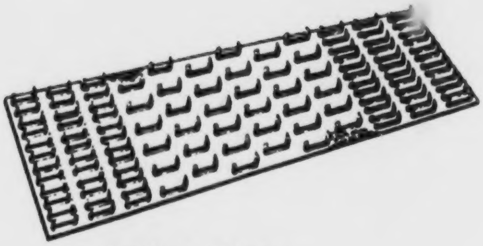
Bolts and Nuts

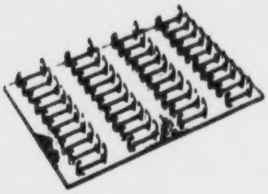


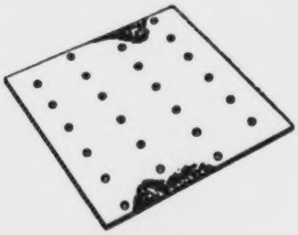
Circular Flat Washer
Circular Ribbed Washer
Plate Washer

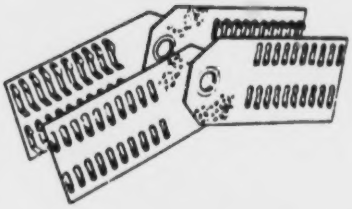
Washers

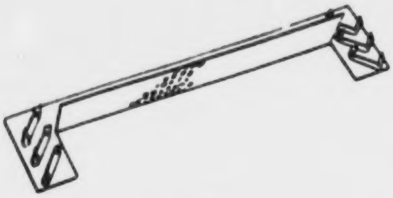
Framing Connectors

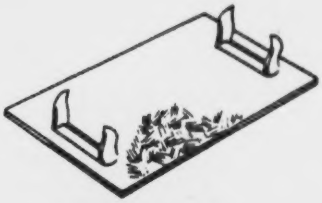

Splice Plate

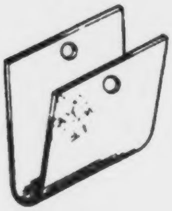

Connector

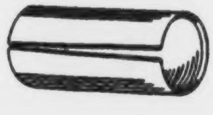

Nail Plate


Hinge Plate

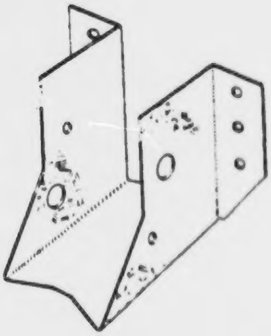

Web


Safety Plate

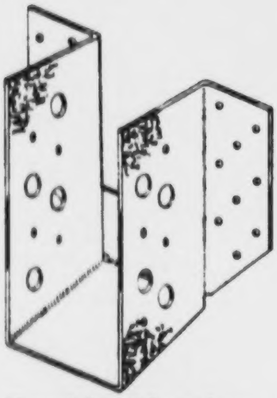

U-Clip


Romex

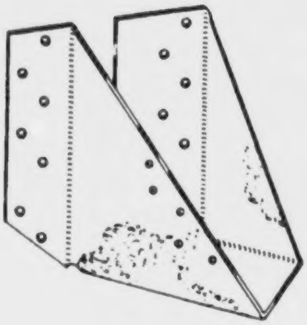
Framing Connectors
(continued)



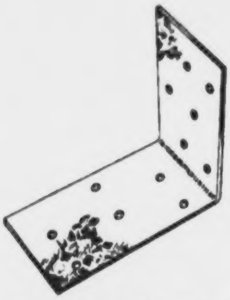
Hanger



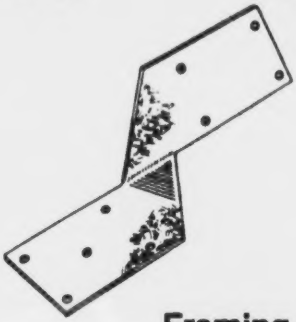
Double Member Girder Hanger



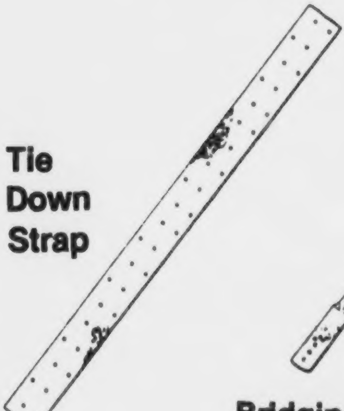
45° Hip Jack Hanger



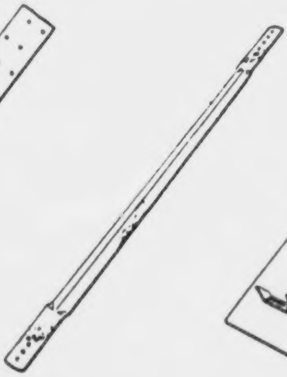
90° Angle Clip



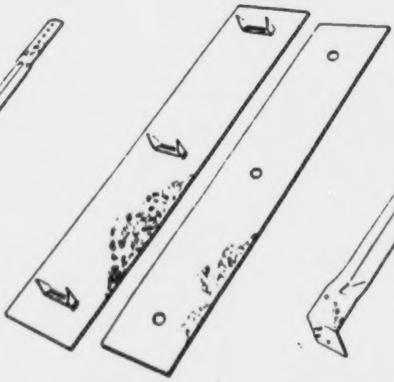
Framing Anchor



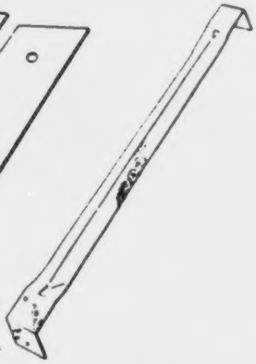
Tie Down Strap



Bridging

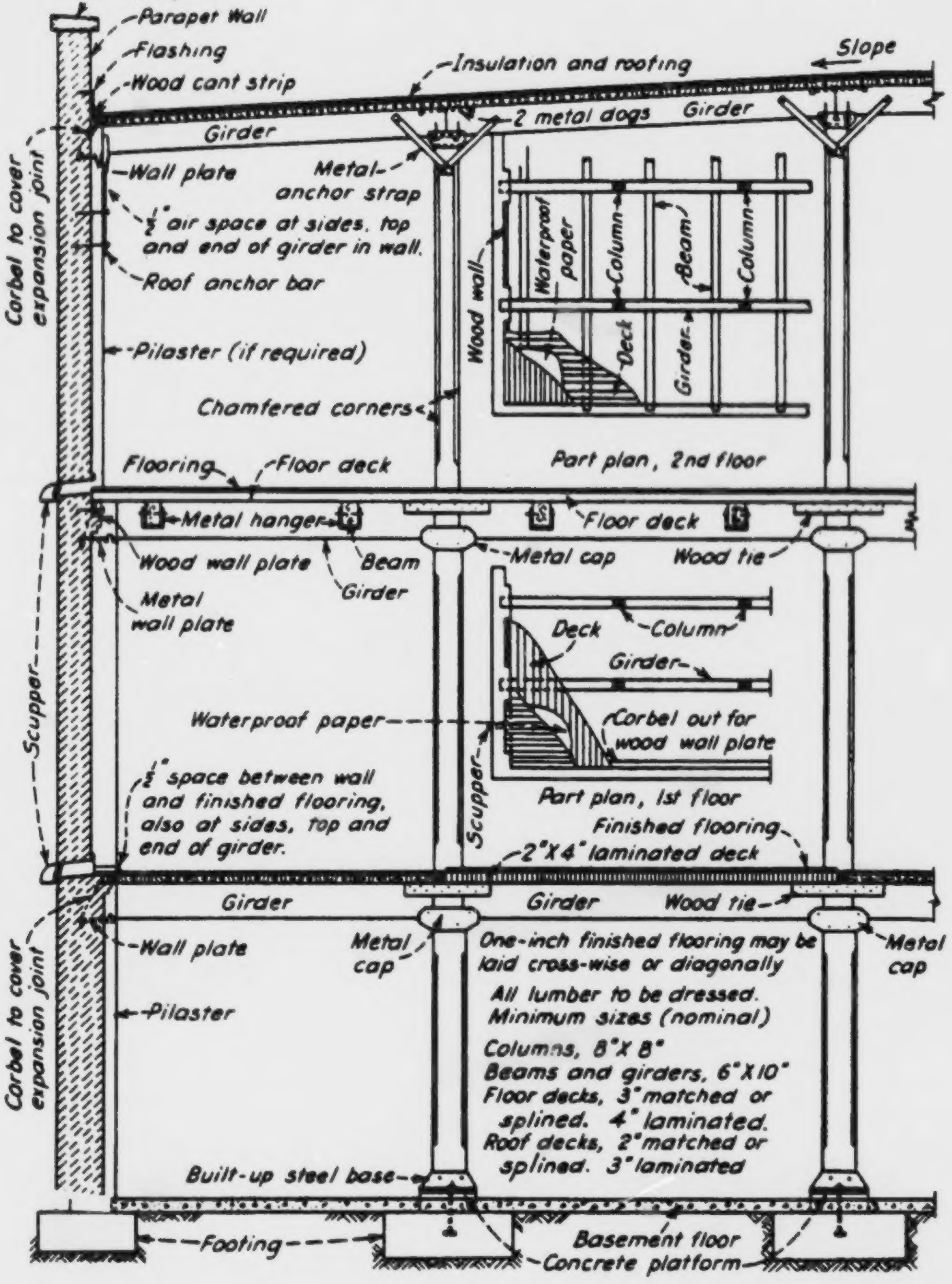


Seat Plates



Truss Spacer

Heavy Timber Construction


Coping
Parapet Wall
Flashing
Wood cant strip
Insulation and roofing
Slope
2 metal dogs
Girder
Girder
Corbel to cover expansion joint
Wall plate
Metal-anchor strap
½" air space at sides, top and end of girder in wall.
Roof anchor bar
Pilaster (if required)
Wood wall
Waterproof paper
Column
Beam
Column
Deck
Girder
Chamfered corners
Part plan, 2nd floor
Flooring
Floor deck
Metal hanger
Floor deck
Wood wall plate
Beam
Metal cap
Wood tie
Metal wall plate
Girder
Deck
Column
Girder
Scupper
Waterproof paper
Corbel out for wood wall plate
Scupper
½" space between wall and finished flooring, also at sides, top and end of girder.
Part plan, 1st floor
Finished flooring
2"X4" laminated deck
Girder
Girder
Wood tie
Wall plate
Metal cap
Metal cap
Corbel to cover expansion joint
Pilaster
Built-up steel base
Footing
Basement floor
Concrete platform

One-inch finished flooring may be laid cross-wise or diagonally

All lumber to be dressed.
Minimum sizes (nominal)

Columns, 8"X 8"
Beams and girders, 6"X 10"
Floor decks, 3" matched or splined. 4" laminated.
Roof decks, 2" matched or splined. 3" laminated

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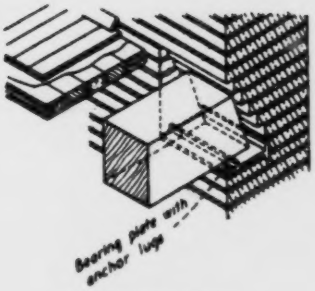
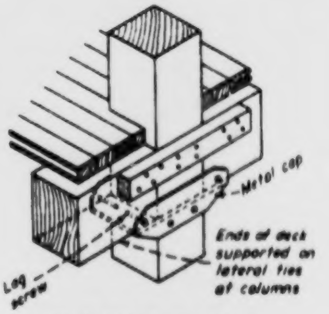
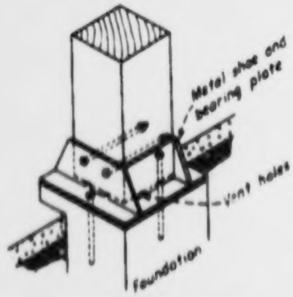
Heavy Timber Construction
(continued)


Bearing plate with anchor lugs

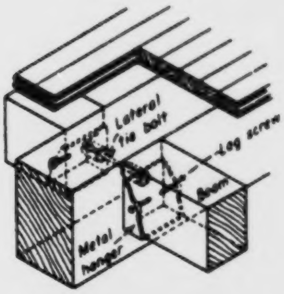
Girder Bearing on Metal Plate Wall


Metal cap
Ends of deck supported on lateral ties at columns
Lag screw

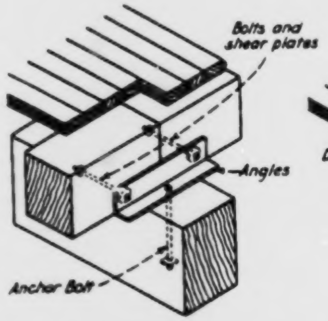
Metal Column Cap with Two Brackets


Metal shoe and bearing plate
Vent holes
Foundation

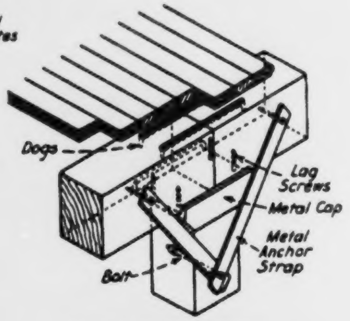
Built-Up Steel Column


Lateral tie bolt
Lag screw
Beam
Metal hanger

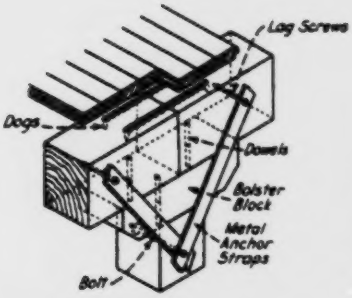
Metal Beam Hanger


Bolts and shear plates
Angles
Anchor Bolt

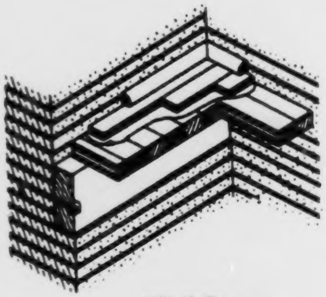
Beams Supported on Top of Girder


Dogs
Lag Screws
Metal Cap
Metal Anchor Strap
Bolt

Metal Column Cap Supporting Roof Girders


Lag Screws
Dogs
Dowels
Bolster Block
Metal Anchor Straps
Bolt

Wood Bolster Block Supporting Roof Girders



Wall Beam

Courtesy of the National Lumber Manufacturers' Association

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TM 18

Unit 11 Construction Surveying

Unit Contents

Teacher Components

Teacher Page

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Answers to Written Test 11–11

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Transparency Masters

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2—2″ x 2″ Hub 11–17
3—Hub to Existing Structure 11–19
4—Typical Grading Plan 11–21

Student Components

Student Page

Objective Sheet 11–3

Information Sheet 11–5

Assignment Sheets

1—Develop Multiple Profiles to Determine Total Volume of Earthwork 11–11
2—Establish a Grade Plan and Determine Cut and Fill for a Cabin Site 11–15
3—Develop a Grading Plan for the MAVCC Topographic Survey Site 11–17

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

Teaching Suggestions

- Take students to a construction site during the different phases of setting a structure on site.
- Have students shadow a surveyor during a construction survey.
- Obtain several sets of construction plans and have the students compare them.
- Display in the classroom grade stakes and hubs.
- Conduct a field trip to a potential construction site and have students identify possible reference points.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

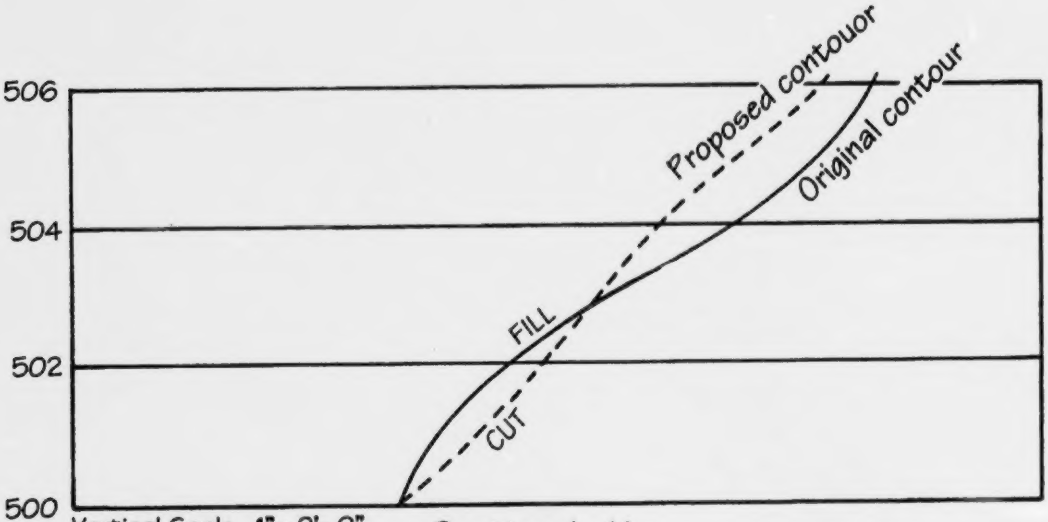
- Brinker, Russell C. and Paul R. Wolf, *Elementary Surveying*, 9th ed. New Jersey: Prentice-Hall, Inc., 1998.
- Colley, Barbara C. *Practical Manual of Land Development*, 3rd ed. New York: McGraw-Hill, Inc., 1998. ISBN 0-07-0119678.
- McCormac, Jack C. *Surveying Fundamentals*, 3rd ed. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1995. ISBN 0-13-031162-6.

Answers to Assignment Sheets

Assignment Sheet 1

Develop Multiple Profiles to Determine Total Volume of Earthwork

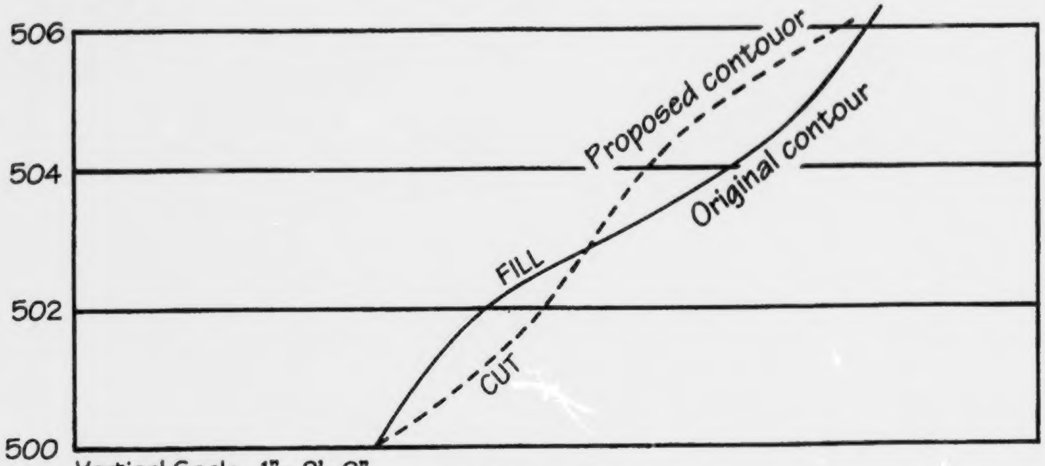
Profile A—A'



Vertical Scale 1"= 2'- 0"

Section A-A'

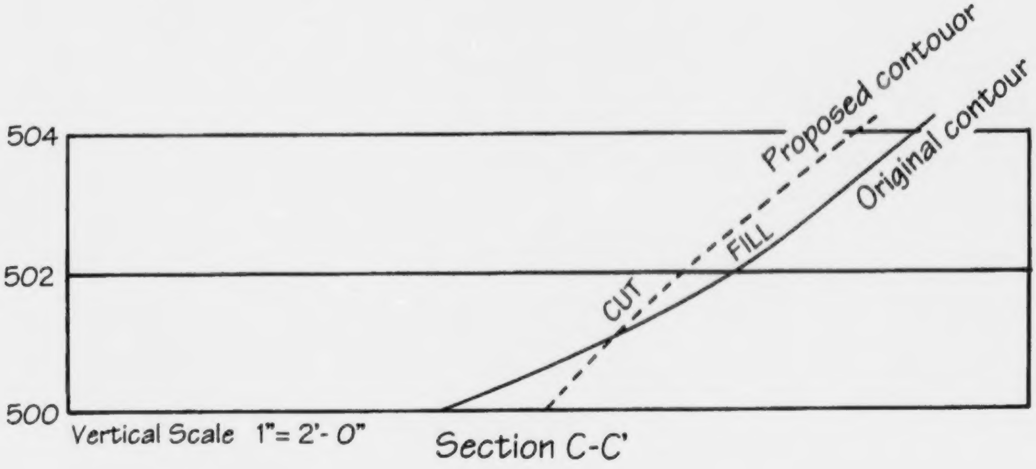
Profile B—B'



Vertical Scale 1"= 2'- 0"

Section B-B'

Profile C—C′


504
502
500
Proposed contouor
Original contour
FILL
CUT
Vertical Scale 1"= 2'- 0"
Section C-C'

Assignment Sheet 2

Establish a Grade Plan and Determine Cut and Fill for a Cabin Site

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 3

Develop a Grading Plan for the MAVCC Topographic Survey Site

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match terms related to construction surveying with their definitions.

1. Construction drawings
2. Contour grading
3. Easement
4. Grade stake
5. Hub
6. Invert elevation
7. Keel
8. Stake

_____ a. An interest or right in land owned by another that entitles its holder to a specific limited use

_____ b. Plans that show size and position of structures that are to be erected, such as buildings, bridges, roads, parking lots, storage tanks, pipelines, etc.

_____ c. Low points on the inside circumference of the pipe

_____ d. A marker that is driven into the ground until its top is at the elevation desired for the finished elevation

_____ e. 1″ x 2″ x 18″ or longer piece of wood sharpened at one end that is driven into the ground to mark a position; may be flagged

_____ f. 2″ x 2″ piece of wood of variable length with a tack driven into it to mark a precise position of a point

_____ g. A blue lumber crayon used to mark stakes that are at grade; commonly used for grading operations along the edges of highways and railroads

_____ h. A contour line used to show proposed finished contours that provide a visual plan view representation of how the finished site will look and how drainage will flow

Objective 2

Define construction surveying.

____

____

____

Written Test

Objective 3

List the four types of surveys used for a construction project.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

Objective 4

Arrange in order the steps for placing a structure on a building site by placing the correct sequence numbers (1 to 9) in the appropriate blanks.

_____ a. Determine minimum setback distances from edge of lot to front edge of structure.

_____ b. Determine building site cut and fill.

_____ c. Develop a grading plan.

_____ d. Structure will be placed at the desired elevations.

_____ e. Plans are developed by an architect using a site map.

_____ f. Establish the correct building dimensions.

_____ g. Contractor for construction job is given a property survey by owner.

_____ h. A preliminary survey is completed.

_____ i. Determine any easements before placement of building corners.

Objective 5

Select true statements about components of a site plan by placing an "X" in the blanks next to the true statements.

_____ a. A site plan includes property boundaries.

_____ b. Site plans are drawn at a large scale: 1" = 10' or 1" = 20'.

_____ c. Site plans do not include contour lines.

_____ d. Site plans show locations of existing structures on the site or adjacent to it.

Objective 6

List the two components of a final plot plan.

a. ____________________

b. ____________________

Objective 7

List one key component of a preliminary construction survey.

____

Written Test

Objective 8

Select true statements about the purpose of a grading plan by placing an "X" in the blank(s) next to the true statement(s).

_____ a. The backs of survey stakes give information on the vertical location to reference points.

_____ b. Grading plans provide elevations at appropriate locations with 3" x 3" wooden hubs and wooden stakes.

_____ c. Stakes identify the elevation and the amount of cut or fill required above or below the top of the hub.

Objective 9

List six elements of a grading plan.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Objective 10

Select true statements about the purpose of grade stakes by placing an "X" in the blanks next to the true statements.

_____ a. Grade stakes are not necessary for sewers, street pavements, and railroads.

_____ b. Grade stakes are used to mark required cut and fill.

_____ c. Grade stakes are used to establish elevations that guide the contractor so the project is constructed to the required elevations.

_____ d. Grade stakes are set at points that have the same ground and grade elevation.

Objective 11

Arrange in order the steps taken to establish a grade stake by placing the correct sequence numbers (1 to 4) in the appropriate blanks.

_____ a. The stake is driven into the ground until the required rod reading is obtained.

_____ b. A set of batter boards and reference stakes are erected near each corner.

_____ c. The survey determines the required elevation of a point and subtracts it from the H.I.

_____ d. The above step establishes the rod reading when the top of the stake is at the desired elevation.

Written Test

Objective 12

List four factors in referencing points for construction.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

Objective 13

Arrange in order the steps to establish the required cut and fill for a building site by placing the correct sequence number (1 to 8) in the appropriate blanks.

_____ a. Draw the construction lines perpendicular from the cutting line from both the original contours and the new proposed contours to a profile grid.

_____ b. Cutting lines through the building site five to ten feet apart and calculating the areas to be cut or filled will determine the total volume of earth to be moved.

_____ c. Plot original contours of the site on a plan view.

_____ d. A cutting line is drawn through the building in the plan view.

_____ e. Mathematical calculations can be utilized to determine the area and volume of earth to be moved.

_____ f. The areas that will require cut or fill work are the areas of discrepancy shown shaded in the profile grid.

_____ g. Determine where the new contours will be and if the building is going to be level or on a slope.

_____ h. Original contours that are required to change are shown as dashed and those that will remain unchanged are shown as solid thin lines.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 3
b. 1
c. 6
d. 4
e. 8
f. 5
g. 7
h. 2

Objective 2

Construction surveying—Transference of the dimensions on a drawing to the ground so the construction work is done in its correct position

Objective 3

a. Property or boundary survey
b. Topographic survey
c. Construction survey
d. As-built survey

Objective 4

a. 4
b. 8
c. 7
d. 9
e. 2
f. 6
g. 1
h. 3
i. 5

Objective 5

a, b, d

Objective 6

a. Location of the building in respect to property lines, streets, and utilities
b. Final contour lines as they will exist after construction is complete

Objective 7

One of the two listed.

a. Shows existing site conditions
b. Includes measurements of horizontal and vertical positions of the foundation of the structure

Objective 8

c

Objective 9

a. Are independent of other site plans
b. Plan's base map is a topographic map and drawn to scale
c. Includes the following:
  - Property boundary
  - Lot and easement lines
  - Sections for the pad and streets
  - Setbacks and structures
  - Cross section for ditches, dikes, and drainage structures
d. Areas of fill are shaded to be different from cut areas
e. Notes
f. Includes tables of cut and fill quantities

Answers to Written Test

Objective 10

b, c, d

Objective 11

a. 3
b. 4
c. 1
d. 2

Objective 12

Any four of the following:

a. Due to the vulnerability of survey stakes during construction, it is necessary to reference to other points (reference points) so a stake can be reestablished if displaced.
b. A reference point should be fairly permanent.
c. A reference point marker could be any of the following:
   - Crosses or marks chiseled into concrete pavement or curbs or sidewalks
   - Nails or bottle caps driven into bituminous pavements or trees
   - Corners of existing buildings
d. Important reference points should be recorded and described in notes in case markings for location at site are obliterated.
e. Reference points are kept to less than 6 feet so points can easily be reestablished with a carpenter's rule and plumb bob.
f. Guard stakes and flags are used to protect a reference point from being disturbed.
g. A common method of refencing is using three points.
h. It is preferred to have reference points set the same distance away from the survey point.

Objective 13

a. 5
b. 8
c. 1
d. 4
e. 7
f. 6
g. 2
h. 3

Prerequisites: Units 1 through 8

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 and 2 to familiarize yourself with common terms used in construction surveying.

☐ 4. **Study** Information Sheet, Objectives 3 through 13.

☐ 5. **Do** Assignment Sheet 1, "Develop Multiple Profiles to Determine Total Volume of Earthwork."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 5 and 6.

☐ 7. **Do** Assignment Sheet 2, "Establish a Grade Plan and Determine Cut and Fill for a Cabin Site."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 7 and 8.

☐ 9. **Go** To computer and complete Assignment Sheet 3, "Develop a Grading Plan for the MAVCC Topographic Survey Site."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat steps 9 and 10.

Learning Activities Sheet

☐ 11. **Check** With instructor for any additional assignments to be completed.

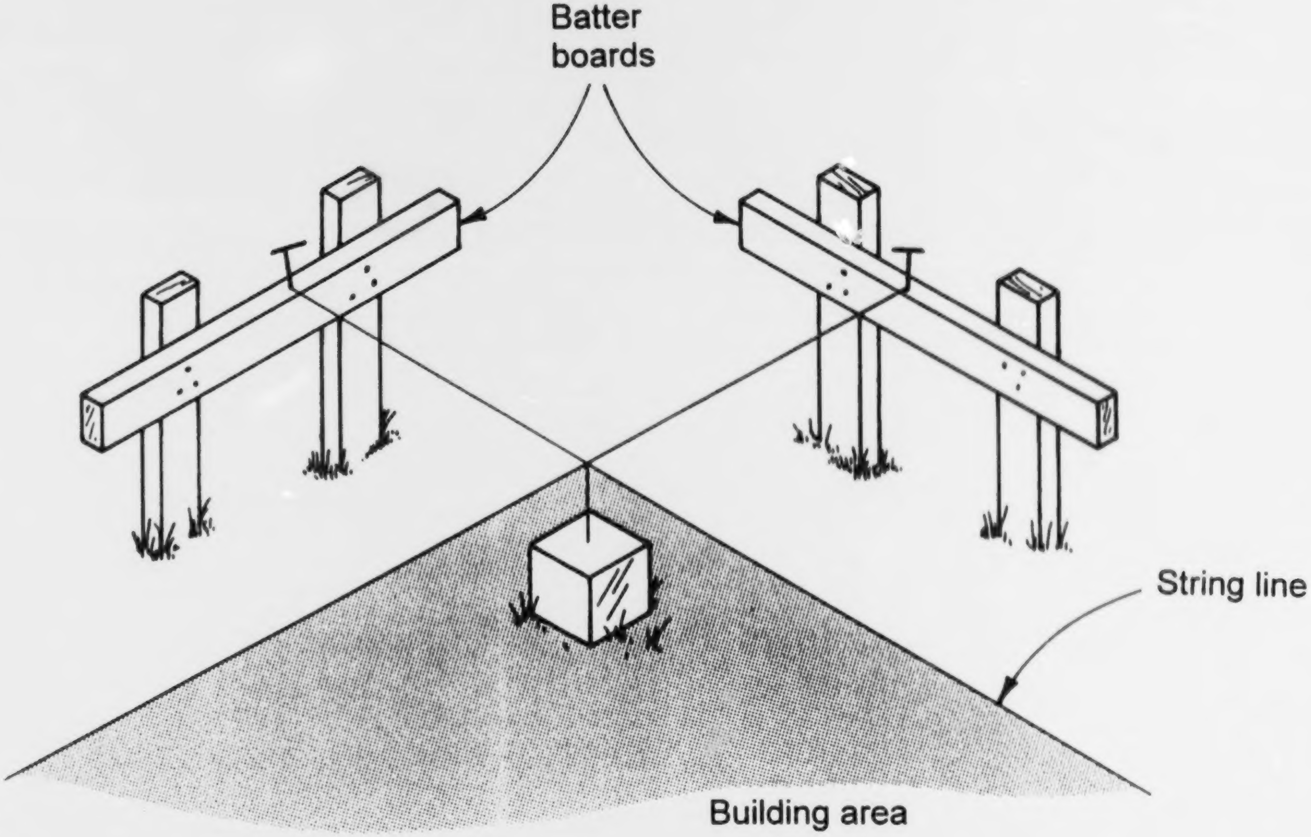
☐ 12. **Do** Additional assignments listed below.

☐ 13. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 14. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

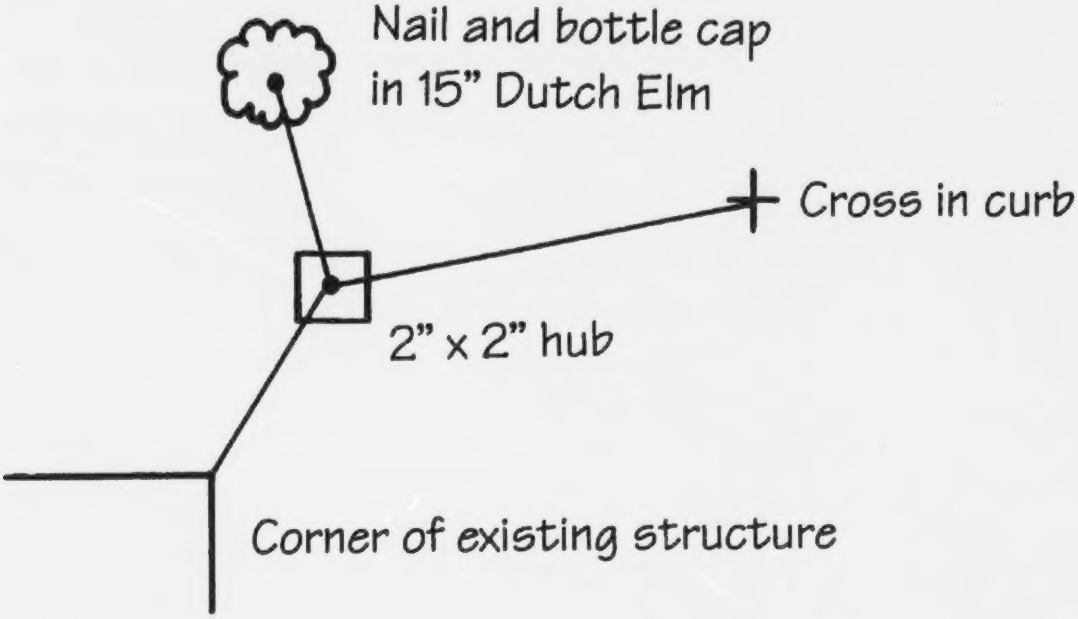
***Permission to duplicate this form is granted.**

Batter Boards

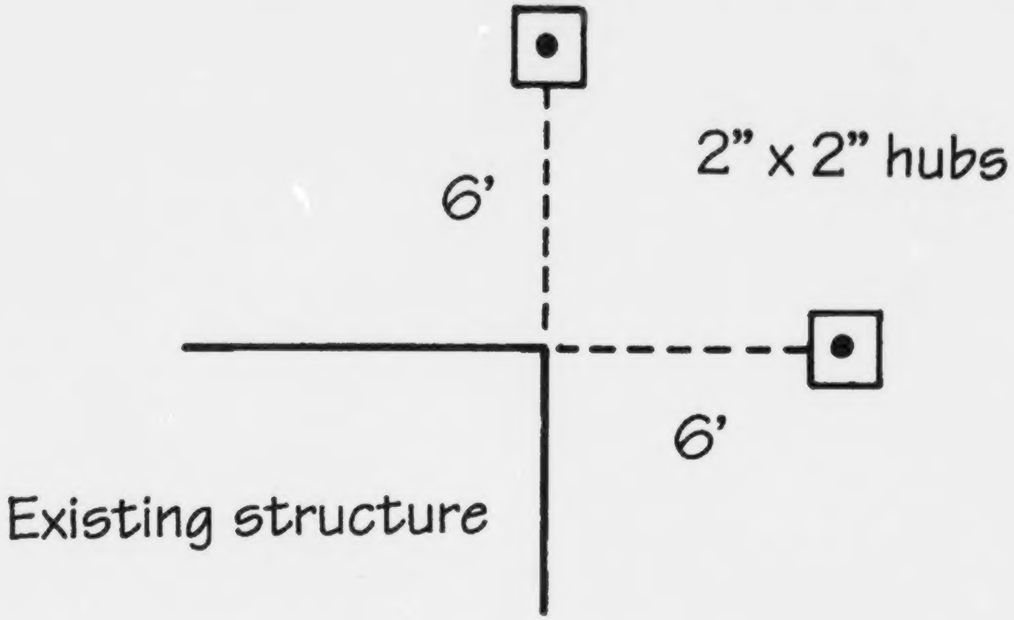

Batter boards
String line
Building area

ELEMENTARY SURVEYING 9/E by Wolf/Brinker, ©1998.
Reprinted by permission of Prentice-Hall, Inc., Upper Saddle River, NJ.

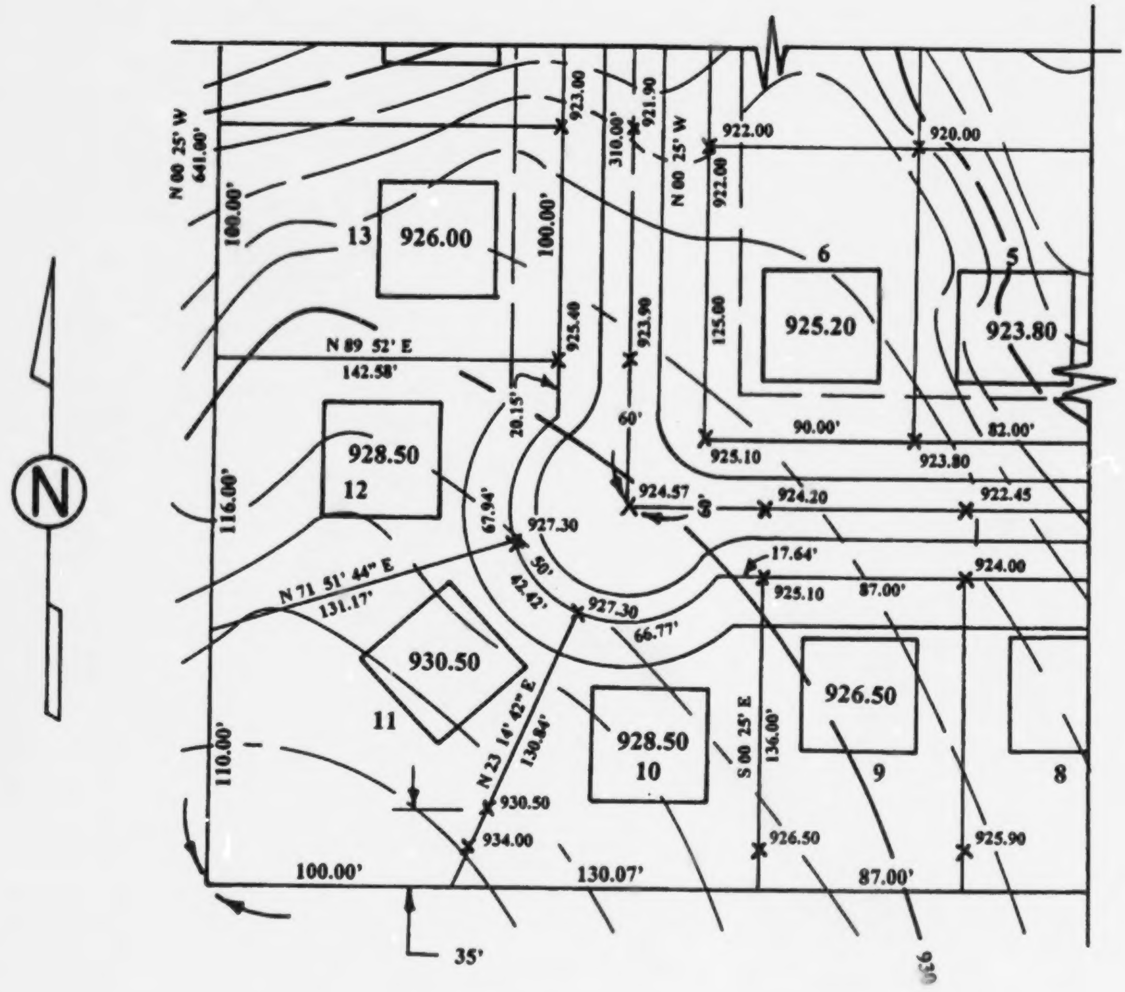
2″ x 2″ Hub


Nail and bottle cap
in 15" Dutch Elm
Cross in curb
2" x 2" hub
Corner of existing structure

Hub to Existing Structure


2" x 2" hubs
6'
6'
Existing structure

Typical Grading Plan


N
N 00 25' W
641.00'
100.00'
13
926.00
100.00'
923.00
310.00'
921.90
N 00 25' W
922.00
922.00
920.00
6
5
925.20
923.80
125.00
N 89 52' E
142.58'
925.40
923.90
60'
20.15'
90.00'
82.00'
925.10
923.80
928.50
12
116.00'
924.57
60'
924.20
922.45
67.94'
927.30
50'
42.42'
17.64'
925.10
87.00'
924.00
N 71 51' 44" E
131.17'
927.30
66.77'
930.50
11
926.50
N 23 14' 42" E
130.84'
928.50
10
S 00 25' E
136.00'
9
8
110.00'
930.50
934.00
926.50
925.90
100.00'
130.07'
87.00'
35'
930

BROOKE HOLLOW

SCALE:
APPROVED BY:
DRAWN BY:
DATE:
REVISED:

ROGER GROSE, PROFESSIONAL ENGINEER
P.O. BOX 2371 STILLWATER, OK 74076
PH. (4050 787-4609

GRADING PLAN
DRAWING NUMBER:

BEST COPY AVAILABLE

Unit 12

Procedures for the Preparation of Maps and Plans

Unit Contents

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Teacher Page

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Student Components

Student Page

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Information Sheet 12-5
Assignment Sheets
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  2—Prepare a Final Presentation of the MAVCC Topographic Survey Map 12-23
Job Sheet
  1—Use a Polar Planimeter to Determine Acreage 12-25

Instructional Plan

Suggested Activities

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Suggested Activities

- Discuss and demonstrate the job sheet. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of this activity and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Write to software vendors for current catalogs for newest applications of mapping software.
- Refer to MAVCC's *Basic Drafting* publication to review inking techniques and the use and care of technical pens.
- Acquire sets of working drawings from different firms and compare style and format of the drawings.
- Set up a demonstration for current techniques for a set of drawing standards.
- Write to your state highway department for a set of drawing standards.
- Visit a local civil engineering firm and observe the presentation methods they use.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Evaluate the job sheet. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

- Aerial photographs.

  — U.S. Geological Survey, EROS Data
  Center, Customer Service, Sioux Falls, SD 57198.
  Phone: 605-594-6151
  Internet: CUSTSERV@edcmail.er.usgs.gov

  — USDA—ASCS, Aerial Photography Field Office
  P.O. Box 30010
  222 West 2300 South
  Salt Lake City, UT 84130-0010

  To order, send a map outlining your area of interest to either of these given addresses.

- Blanchard, Robert. *Pin Register Graphics.* Palo Alto, CA: Robert Blanchard.

Suggested Activities

- Cartographic data on CD-ROM. Earth Science Information Center (ESIC). To order, call 1-800-USA-MAPS.
- Madsen, David and Terence Schumaker. *Civil Drafting Technology,* 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1997.
- USGS Map Separates. U.S. Department of the Interior, ESIC (Earth Science Information Center). To order, call 1-800-USA-MAPS.
- Wattles, Gurdon. *Survey Drafting,* 2nd ed. Orange, CA: Gurdon H. Wattles Publications, 1981.
- Wirshing, Roy H. and James R. Wirshing. *Civil Engineering Drafting.* New York: Glencoe/McGraw-Hill Inc., 1983, Imprint 1993.

Answers to Assignment Sheets

Assignment Sheet 1

Complete a Tracing in Ink of a Mapped Area

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 2

Prepare a Final Presentation of the MAVCC Topographic Survey Map

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match terms related to preparation of maps and plans with their definitions.

1. Acetate
2. Gloss
3. Matte
4. Medium
5. Mylar
6. Opaque
7. Polyester film
8. Reproducible
9. Sensitized material
10. Translucent
11. Transparent
12. Vellum

_____ a. A surface that has a bright, polished finish

_____ b. Brand name of a polyester film used as a base for drawing in the drafting industry

_____ c. Admitting and diffusing light so that objects beyond cannot be clearly distinguished; partly transparent

_____ d. A clear plastic film which has no drafting surface

_____ e. A drawing medium that is matte on one or both sides for a drafting surface; accepts both ink and pencil and comes in various mil thicknesses

_____ f. A material used to carry information; in drafting, includes various papers and films used for written and drafted information

_____ g. An original drawing on a translucent material suitable for diazo reproduction

_____ h. A diazo product used in the reproduction process of maps and topos; either negative or positive images can be placed on this film with more drafting added later as needed

_____ i. A slightly rough finish free from shine or highlights

_____ j. Not permitting the passage of light

_____ k. Transmitting light without appreciable scattering so that bodies lying beyond are clearly visible

_____ l. A prepared tracing paper that has the quality of strength and transparency to make a good drawing surface; generally used with pencil and ink

Written Test

Objective 2

Match types of drafting media with their characteristics.

1. Gridded media
2. Tracing and drawing polyester films
3. Natural tracing paper
4. Prepared tracing paper (vellum)

_____ a. 100% rag translucent paper which accepts pencil and ink

_____ b. Used for quick notes or changes over a drawing

_____ c. May be sensitized for special diazo reproduction process or unsensitized for standard work

_____ d. Film or paper printed with black or blue 90° grids with single or double matte surfaces

Objective 3

List five methods of drawing reproduction.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

Objective 4

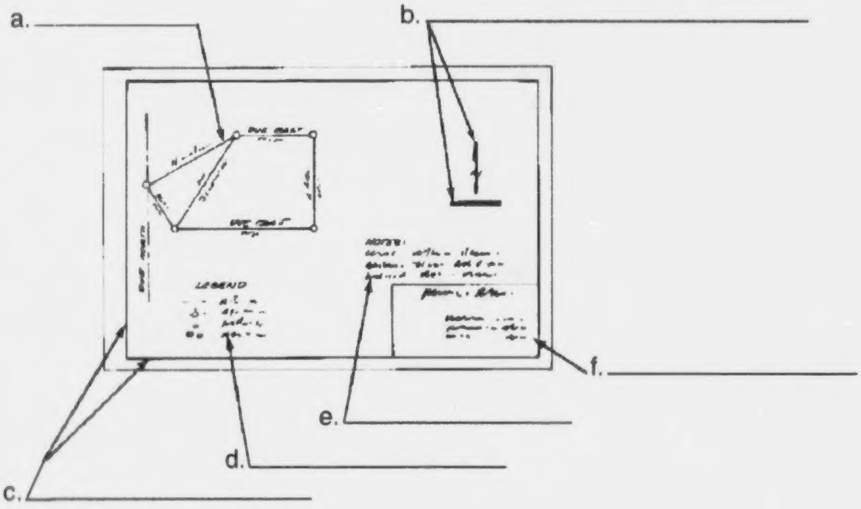
Distinguish between maps and plans by placing an "X" next to the description of a plan.

_____ a. The finished document

_____ b. The documents that illustrate what the finished project will look like

Objective 5

Label the components of the following map layout.



Objective 6

State the purpose of a legend.

____

____

____

Objective 7

Complete the following statements about north (meridian) arrows by circling the word that best completes each statement.

a. Arrow is placed with north generally oriented at the (**top, bottom**) of the map sheet.

b. True, (**scale, grid**), and magnetic north may all be shown on a map.

Objective 8

List two facts about scales and scale bars.

a. ______________________________

____

b. ______________________________

____

Objective 9

List the components of a title block.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

Written Test

Objective 10

Arrange in order the following steps for drafting a map or plan by placing the correct sequence numbers (1 to 8) in the appropriate blanks.

______ a. Lay in the border.

______ b. Locate the north (meridian) arrow.

______ c. Place the title block.

______ d. Letter in the notes.

______ e. Plot in map area on a layout sheet.

______ f. Place the legend.

______ g. Select sheet medium (film or paper) and size.

______ h. Set up for final plot.

Objective 11

List the standard sheet formats for a set of civil drawings.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

Objective 12

List the two methods of map registration.

a. ______________________________

b. ______________________________

Objective 13

Complete the following statements concerning lettering considerations for maps and plans by circling the word(s) that best complete(s) each statement.

a. Lettering usually varies in size on maps in direct relation to the (**location, importance**) of the item to be lettered.

b. Lettering should be placed so it is readable from the bottom and the (**right, left**) hand side of the drawing.

c. Lettering for railroads, roads, and waterways on maps should be parallel and (**close to, to the left of**) the symbol.

d. A name on a map is placed (**under, near**) its feature and with minimum interference with other map detail.

Objective 14

Match useful tools for the creation and production of maps and plans with their descriptions.

1. Stereoscope viewers
2. Aerial photographs
3. Orthophotographs
4. Map separates
5. Spreadsheets
6. Cartographic data
7. Planimeter

______ a. A tool used to determine approximate area of a mapped area

______ b. USGS 7.5 minute quadrangle maps are available in color separates

______ c. Available through CD-ROM or Internet access

______ d. Used to read aerial photographs in stereo

______ e. Used as a base map for line art to show plans for specific area

______ f. Used to verify locations of points on the earth

______ g. Used for preparation of data or calculations

Objective 15

Distinguish among the three types of planimeters by placing the following letters next to the correct descriptions.

(D) Disc planimeter (E) Electronic planimeter (P) Polar planimeter

______ a. Fixed arm type measures areas in square inches or square centimeters, then multiplied by a factor

______ b. Is recommended for use on maps or charts that have been reduced to a small scale

______ c. Has a digital readout of the area measured

______ d. Is considered more precise than the polar planimeter

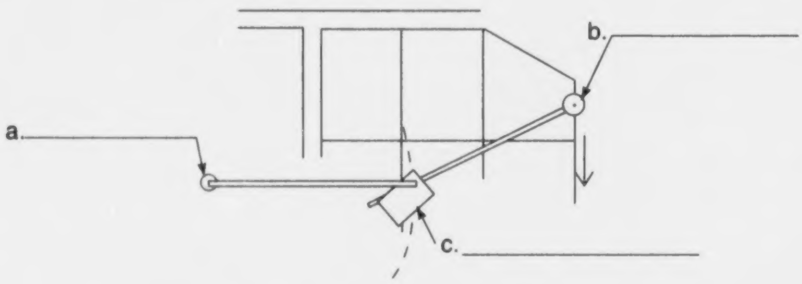
______ e. Adjustable arm type can be set to a variety of ratios for direct reading from the dial

______ f. Minimizes the possibility of decimal mistakes

Written Test

Objective 16

Label the parts of the following polar planimeter.



Objective 17

Complete the following statements related to the applications of aerial photography by circling the word(s) that best complete(s) each statement.

a. (**Photo map, Photo mosaic**) is a composite of several aerial photos tied together to represent a large area.

b. An orthophoto is an orthographic photograph that results from processing aerial photographs to remove (**fuzziness, distortion**).

c. Analytical aerotriangulation produces coordinates of photo control points by (**mathematical, scientific**) procedures.

Objective 18

Distinguish between advantages and disadvantages of using aerial photography by placing an "A" next to the advantages and a "D" next to the disadvantages.

_____ a. Cost of flying a project

_____ b. Distortion around edges of aerial photos due to curvature of the earth

_____ c. Access to areas difficult to reach by ground

_____ d. Availability of aerial photos for all areas

_____ e. Speed at which work is accomplished

Objective 19

Select true statements concerning aerial photo control by placing an "X" in the blanks next to the true statements.

_____ a. A baseline measurement of two clearly identified points from the ground within the model is required for horizontal control on a stereo model.

_____ b. Baseline measurements should be provided on every model.

_____ c. Eight vertical control points are required, two near each corner of the model.

Written Test

Objective 20

Complete the following statements concerning general facts about aerial photogrammetry by writing in the word(s) that best complete each statement.

a. Photographs may be taken from airplanes, ________________, or ground stations.

b. Aerial photographs are taken in ________________ order, usually with 30 to 60 percent forward overlap and 10 to 30 percent side overlap.

c. The scale of the aerial photo is the ________________ of the camera focal length to the height of the flight above ground.

Objective 21

Arrange in order the steps for using a stereoscope by placing the correct sequence numbers (1 to 4) in the appropriate blanks.

_____ a. Slightly overlap the two photos and set the stereoscope on the photos straddling the overlap.

_____ b. Maneuver the photo so the two images line up, one on top of the other. At this time you should see the photo images in three dimension.

_____ c. Line up the adjoining aerial photographs with common features lined up.

_____ d. Look through the viewers and fix on the landmark. You should see two images of the landmark. (One appears to float.)

Objective 22

List six common mistakes made in map drafting.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 2
b. 5
c. 10
d. 1
e. 7
f. 4
g. 8
h. 9
i. 3
j. 6
k. 11
l. 12

Objective 2

a. 4
b. 3
c. 2
d. 1

Objective 3

Any five of the following:

a. Diazo print
b. Intermediate
c. Xerographic copying
d. Photo engraving
e. Photo offset printing
f. Computer plot

Objective 4

b

Objective 5

a. Mapped area
b. North arrow and scale information
c. Border
d. Legend
e. Notes
f. Title block

Objective 6

Used to represent the different types of symbols found on a map; map symbols are used when a feature shows up more than once on a map

Objective 7

a. top
b. grid

Objective 8

a. Each plan will have the vertical and horizontal scale documented.
b. Written scale and scale bar are generally shown together.

Answers to Written Test

Objective 9

a. Type of map
b. Name of property or project
c. Owner or user
d. Location or area
e. Date completed
f. Scale
g. Contour interval
h. Horizontal and vertical datums
i. Name of surveyor, engineer, or architect and license number where applicable

Objective 10

a. 2
b. 5
c. 4
d. 7
e. 3
f. 6
g. 1
h. 8

Objective 11

a. Cover sheet
b. General notes and design data
c. Quantity sheets
d. Key map
e. Removal and demolition plan
f. Plan and profiles
g. Cross sections
h. Detail sheets
i. Miscellaneous plans

Objective 12

a. Pin registration
b. Register marks

Objective 13

a. importance
b. right
c. close to
d. near

Objective 14

a. 7
b. 4
c. 6
d. 1
e. 3
f. 2
g. 5

Answers to Written Test

Objective 15

a. P
b. D
c. E
d. D or E
e. P
f. E

Objective 16

a. Pole
b. Tracer
c. Counter box

Objective 17

a. Photo mosaic
b. distortion
c. mathematical

Objective 18

a. D
b. D
c. A
d. D
e. A

Objective 19

a

Objective 20

a. satellites
b. sequential
c. ratio

Objective 21

a. 2
b. 4
c. 1
d. 3

Objective 22

Any six of the following:

a. Not checking scaling distances when plotting coordinates
b. Plotting by protractor, not computer
c. Selecting an inappropriate scale or contour interval for the map
d. Improperly orienting topographic notes in field or office
e. Making the north arrow too large, complex, or black
f. Omitting the scale or necessary notes
g. Failing to balance the sheet by making a preliminary sketch
h. Drafting the map on a poor-quality medium

Unit 12

Procedures for the Preparation of Maps and Plans

Prerequisites: Units 1 through 11

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 and 2 to familiarize yourself with common terms used in the preparation of maps and plans.

☐ 4. **Study** Information Sheet 1, Objective 3 through 13.

☐ 5. **Do** Assignment Sheet 1, "Complete a Tracing in Ink of a Mapped Area."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 5 and 6.

☐ 7. **Study** Information Sheet, Objectives 14 through 16.

☐ 8. **Do** Job Sheet 1, "Use a Polar Planimeter to Determine Acreage."

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and the instruction manual for the planimeter, and repeat steps 8 and 9.

☐ 10. **Study** Information Sheet, Objectives 17 through 22.

CAD

☐ 11. **Go** To computer and complete Assignment Sheet 2, "Prepare a Final Presentation of the MAVCC Topographic Survey Map."

Learning Activities Sheet

☐ 12. **Stop** Have instructor evaluate the completed assignment sheet, and if the evaluation is satisfactory, continue to step 13. if the evaluation is not satisfactory, meet with instructor to determine needed improvements, and repeat steps 11 and 12.

☐ 13. **Check** With instructor for any additional assignments to be completed.

☐ 14. **Do** Additional assignments listed below.

____

____

____

☐ 15. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 16. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Percentages of Enlargement or Reduction

Scale Change		*Percentage Enlargement (E) — Reduction (R)
From	To	
1″ = 20′	1″ = 40′ 1″ = 50′ 1″ = 100′ 1″ = 200′	50% R 40% R 20% R 10% R
1″ = 40′	1″ = 20′ 1″ = 50′ 1″ = 100′ 1″ = 200′	200% E 80% R 40% R 20% R
1″ = 50′	1″ = 20′ 1″ = 40′ 1″ = 100′ 1″ = 200′	250% E 125% E 50% R 25% R
1″ = 100′	1″ = 20′ 1″ = 40′ 1″ = 50′ 1″ = 200′	500% E 250% E 200% E 50% R
1″ = 200′	1″ = 20′ 1″ = 40′ 1″ = 50′ 1″ = 100′	1000% E 500% E 400% E 200% E

* Stated in % of original size

For percentages to enlarge or reduce scales not shown, divide the desired into the existing:

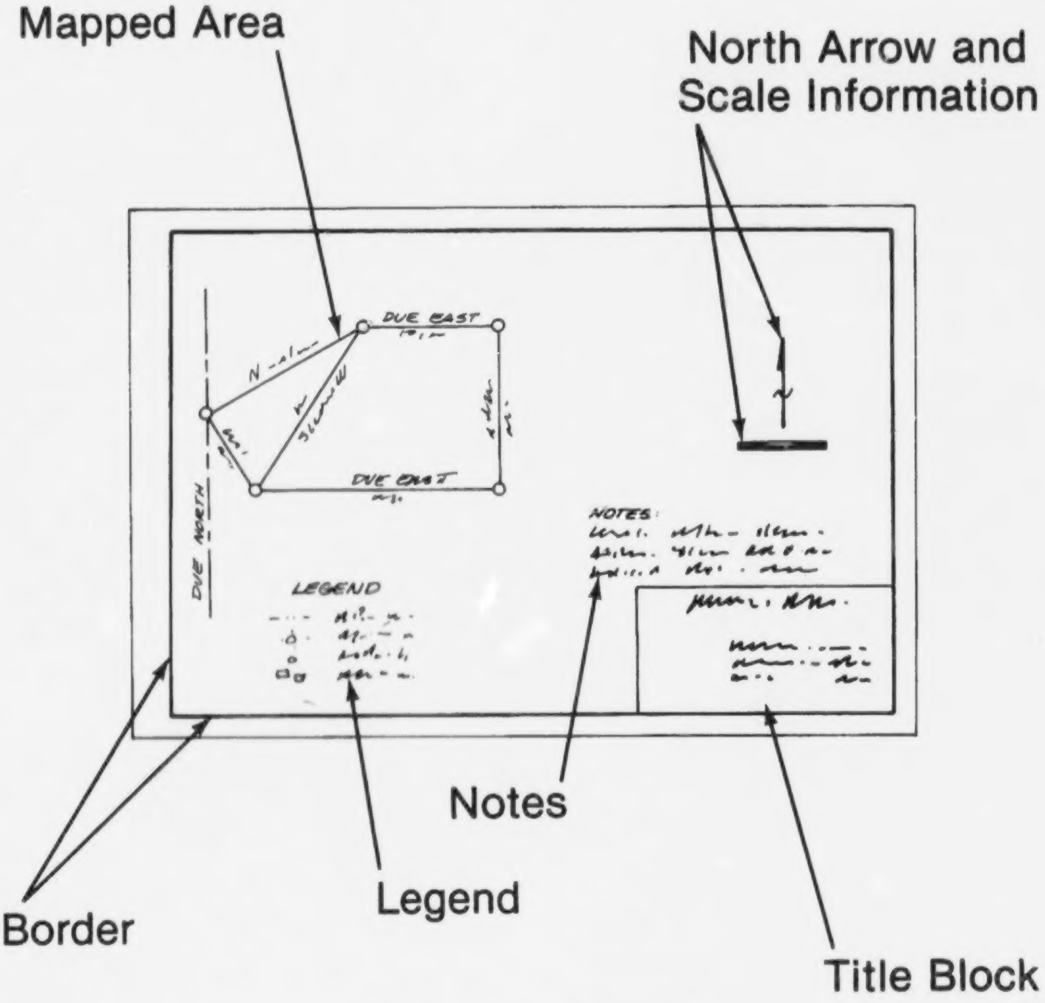
$$\frac{\text{Exist. Sc.}}{\text{Des. Sc.}} = \text{\% of E or R}$$

For percentages to enlarge or reduce inches to inches:

Enlarging—divide smaller number into larger $\frac{\text{Lg. No.}}{\text{Sm. No.}} = \text{\% of E}$

Reducing—divide larger number into smaller $\frac{\text{Sm. No.}}{\text{Lg. No.}} = \text{\% of R}$

Components of a Map Layout


Mapped Area
North Arrow and Scale Information
DUE EAST
DUE EAST
DUE NORTH
NOTES:
LEGEND
Notes
Legend
Border
Title Block

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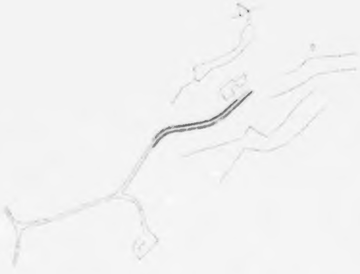
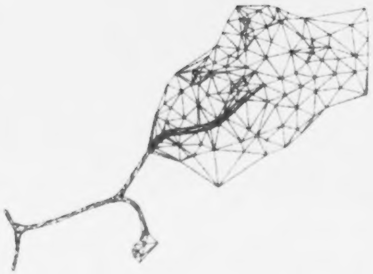
MAVCC Topographic Survey Map Project

- Final Presentation
- Points.dwg
- Lot.dwg
- Tin.dwg
- Contour.dwg
- Fault.dwg
- Linework.dwg
- Legend.dwg

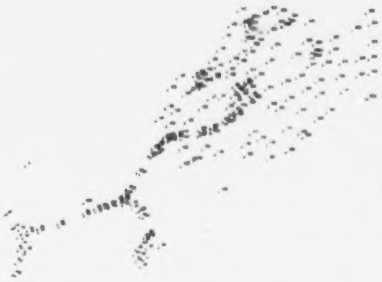
Final Presentation



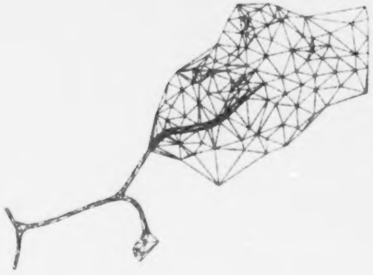
FAULT.DWG



TIN.DWG



POINTS.DWG



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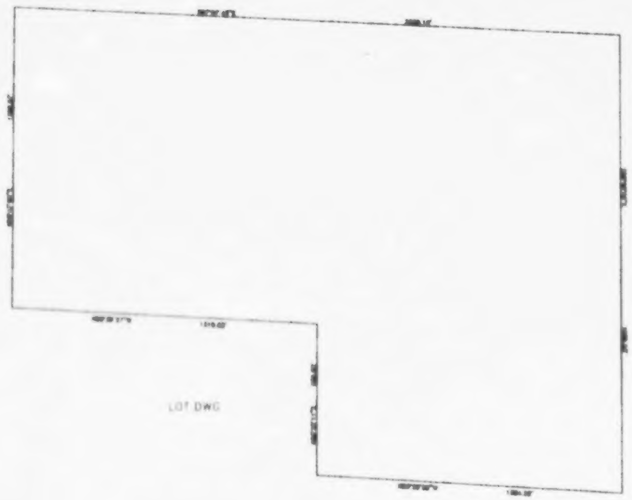
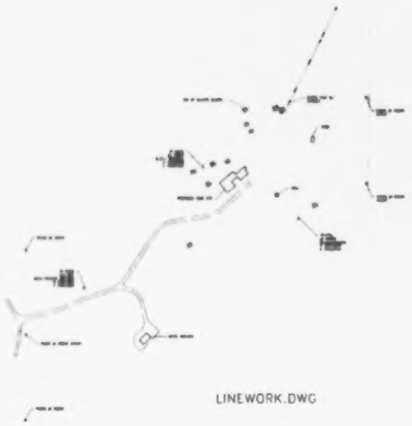


LOT.DWG

LEGEND.DWG



LINEWORK.DWG

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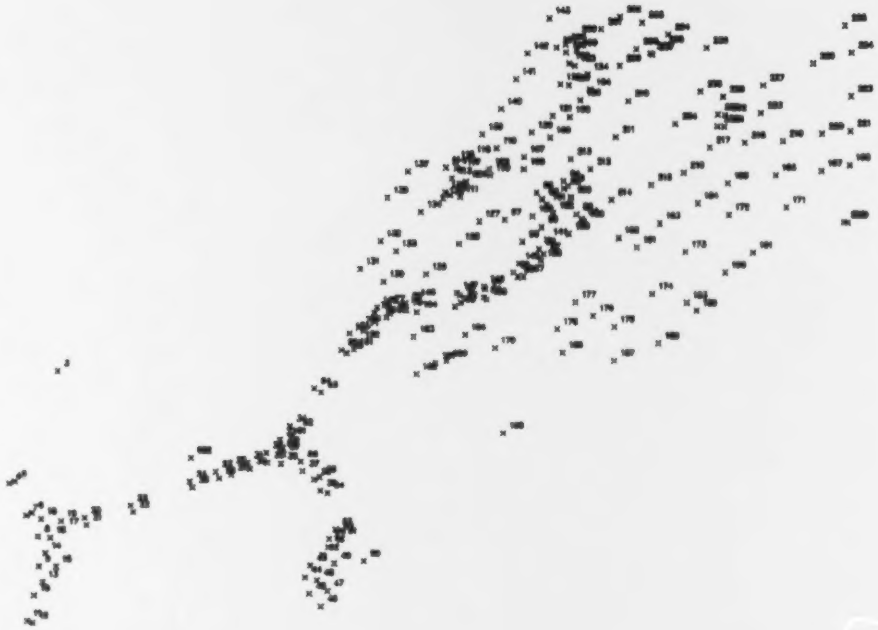

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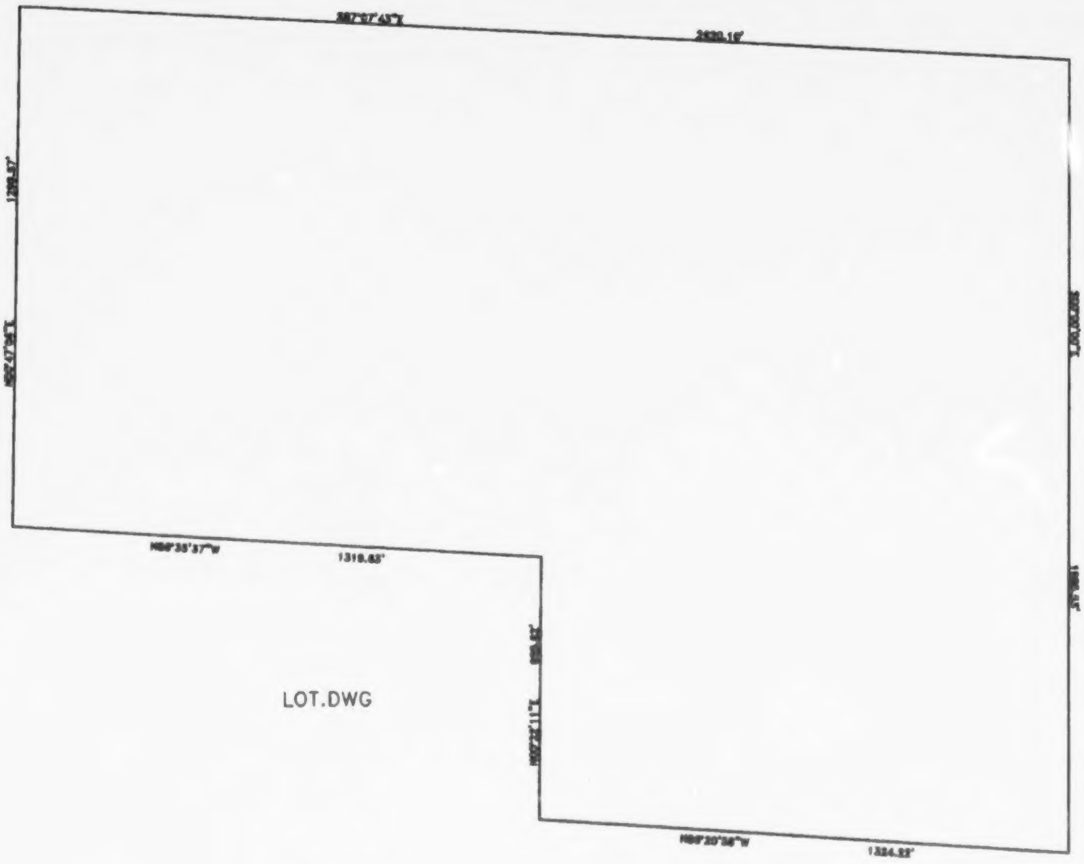
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N88°35'37"W
1319.63'
LOT.DWG
N88°20'38"W
1324.33'

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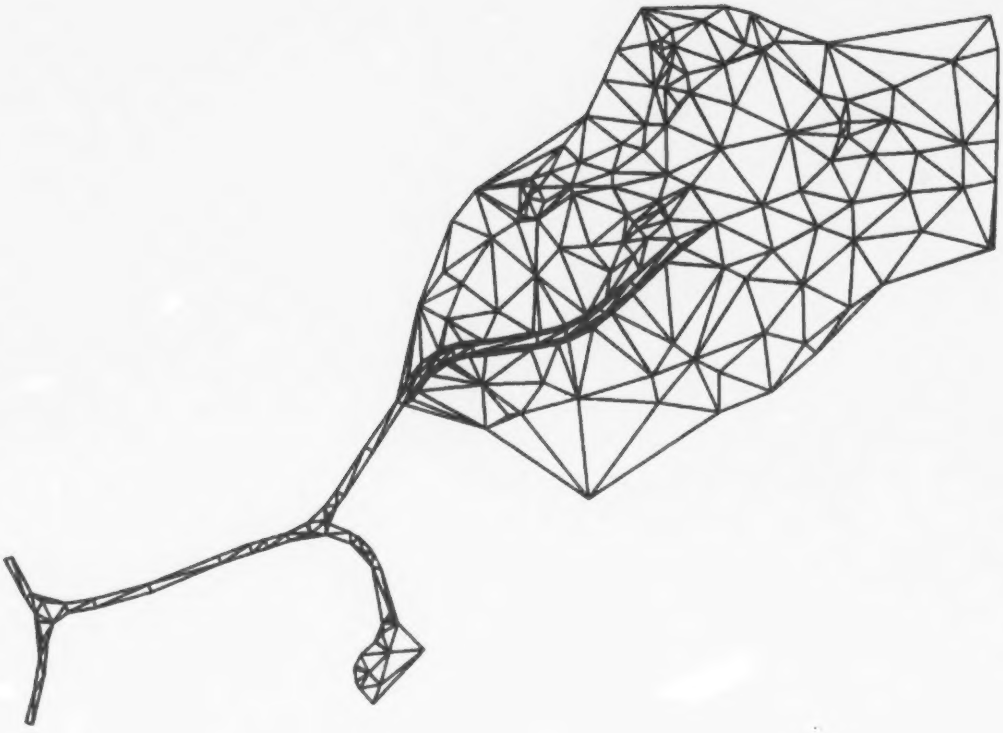

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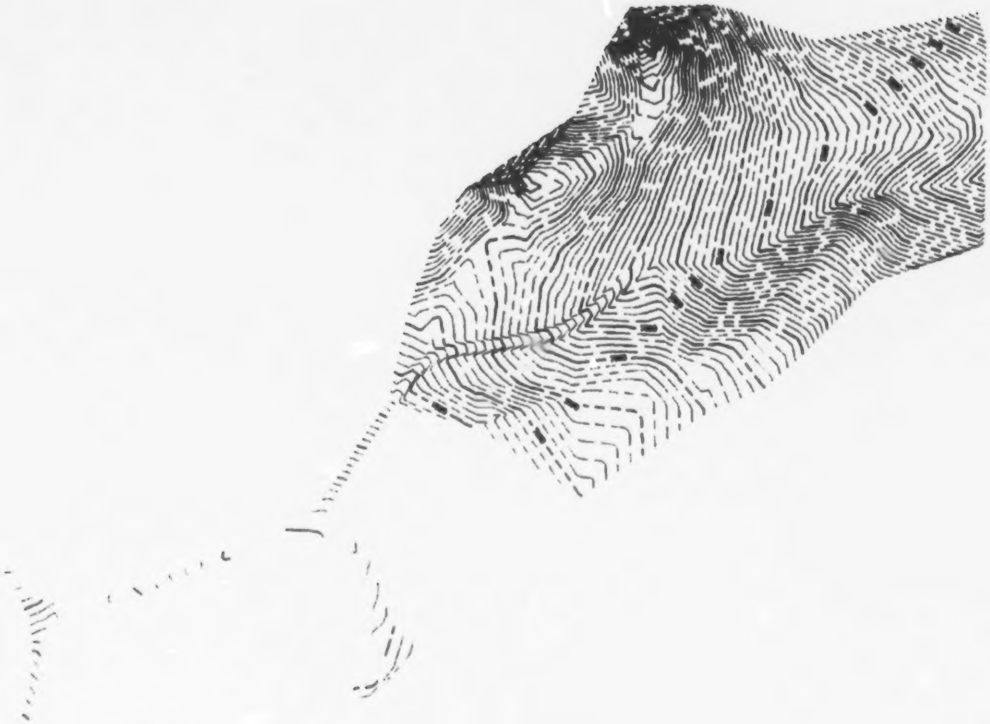
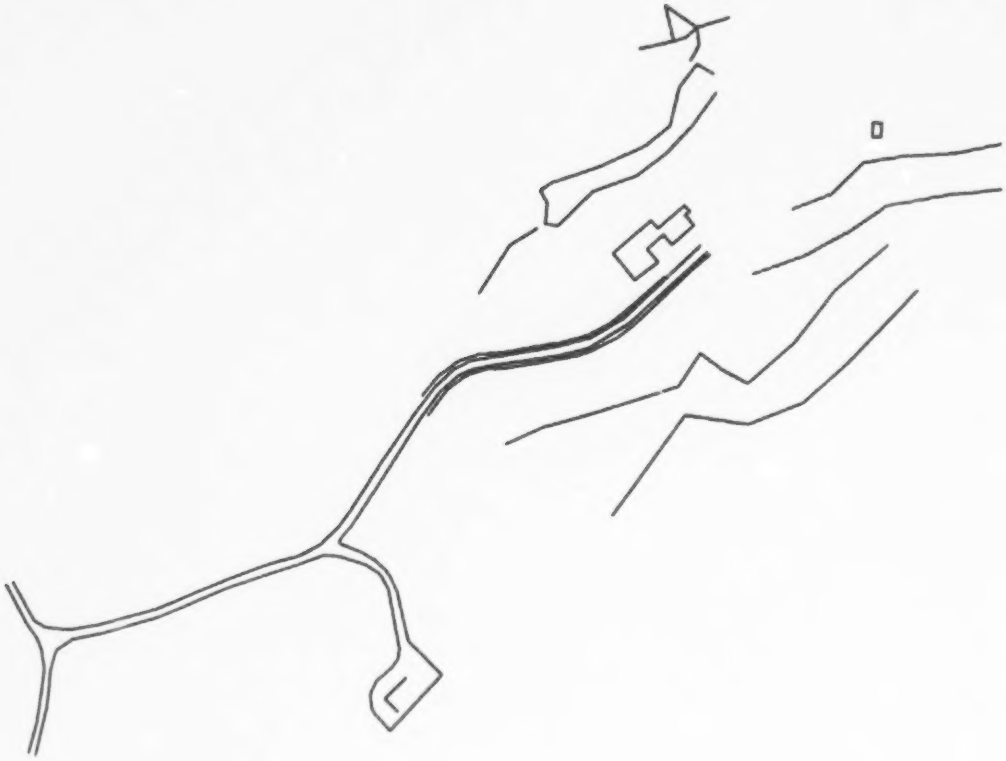


CONTOUR.DWG



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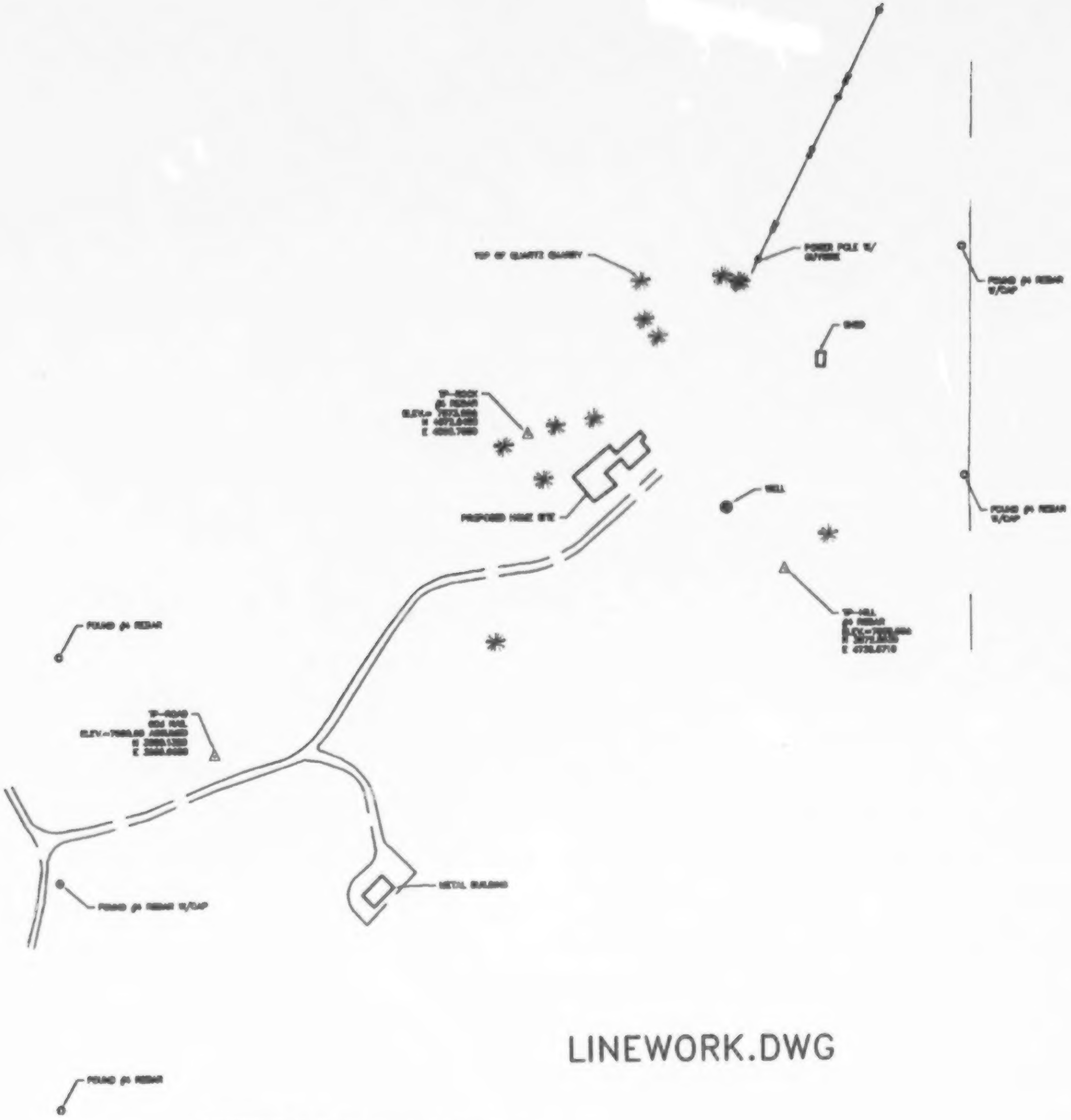
TOP OF QUARTZ QUARRY
POWER POLE W/ GUYWIRE
FOUND #4 REBAR W/CAP
SHED
TP-ROCK
#5 REBAR
PROPOSED HOME SITE
WELL
FOUND #4 REBAR W/CAP
TP-HILL
#5 REBAR
E 4735.0710
FOUND #4 REBAR
TP-ROAD
60d NAIL
FOUND #4 REBAR W/CAP
METAL BUILDING
FOUND #4 REBAR

LINEWORK.DWG

459

460

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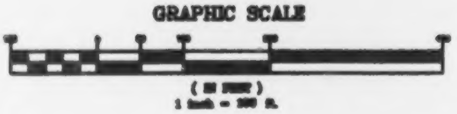
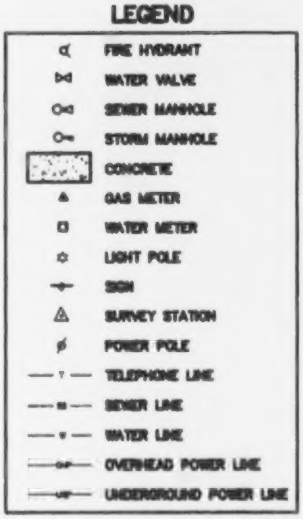

GRAPHIC SCALE


LEGEND
FIRE HYDRANT
WATER VALVE
SEWER MANHOLE
STORM MANHOLE
CONCRETE
GAS METER
WATER METER
LIGHT POLE
SIGN
SURVEY STATION
POWER POLE
TELEPHONE LINE
SEWER LINE
WATER LINE
OVERHEAD POWER LINE
UNDERGROUND POWER LINE

LEGEND.DWG

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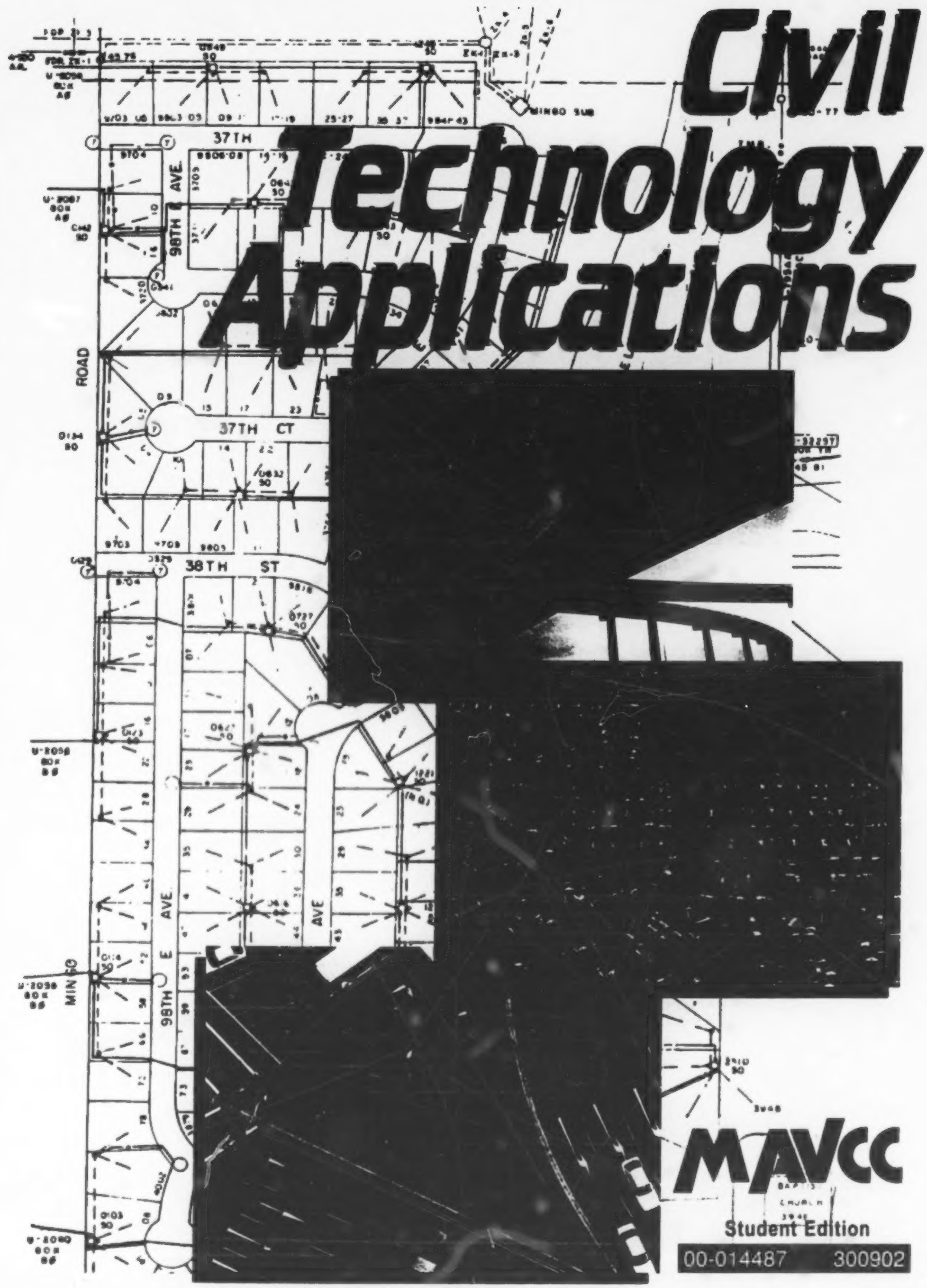
Civil Technology Applications


37TH
98TH E AVE
ROAD
37TH CT
38TH ST
MINGO
98TH E AVE
AVE
MINGO SUB
BAPTIST CHURCH

MAVCC

Student Edition

00-014487 300902

Civil Technology Applications

Student Edition

Written and revised by

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Developed by

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Stillwater, Oklahoma 74074-4364

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Unit 6: Interpretation of Surveyor's Notations
Unit 7: Topographic Mapping
Unit 8: Municipal Mapping, Plats and Subdivisions
Unit 9: Transportation Mapping
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Introduction to Civil Technology Applications

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Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify types of maps and drawings used by civil technicians and access the Internet to look up mapping resources. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to civil technology applications with the correct definitions.
2. Select required skills of a civil technician.
3. List job responsibilities of a civil technician.
4. List major employment opportunities for a civil technician.
5. Distinguish between organization structures of design teams in small and large firms.
6. List specialty areas for civil engineering firms.
7. Select occupations related to civil drafting.
8. Identify major types of maps.
9. Match major types of maps with their correct characteristics.
10. Match typical drawings used in civil drafting with the correct uses.
11. Identify drafting equipment used by civil technicians.
12. Interview a civil technician. (Assignment Sheet 1)
13. Research possible employment opportunities in civil drafting technology in your local area. (Assignment Sheet 2)
14. Access the Internet for mapping resources. (Assignment Sheet 3)

Information Sheet

Objective 1

Terms and definitions

a. **Bathymetric map**—Map delineating the form of the bottom of a body of water by using depth contours

b. **CAD**—Computer-aided drafting or design

c. **CAM**—Computer-aided mapping

d. **Cartography**—The science of making maps and charts

e. **Chart**—Special-purpose map designed for navigation or to present specific data or information; chiefly used for nautical and aeronautical navigation

f. **Civil drafting technician**—A person who supports civil engineering with the preparation of technical materials, participates as a member of a design team, and acts as a link between field work and final map preparation

Examples: Maps, engineering calculations, interpretation of surveying notes, data related to the design of civil projects, checker, and computer drawings

g. **Civil engineer**—A person who has completed a minimum of four years of college and has specialized in civil-related engineering

h. **Civil engineering**—A discipline concerned with the design and construction of various municipal and state projects for the general public, such as bridges, roads, dams, canals, pipelines, and drainage

i. **Contour line**—A line used to connect points on a land surface that have the same elevation

j. **Culture**—Features on a map that are constructed by man

Examples: Road, building

k. **Elevation**—Altitude or height above sea level

l. **Geodetic survey**—A precise survey of considerable extent which takes into account the shape of the earth

m. **Geographic**—Signifying basic relationship to the earth considered as a globe-shaped body; applies to data based on the geoid and on the spheroid

n. **Hypsographic map**—Map showing relief with elevations referred to the national geodetic vertical datum of 1929

o. **Hypsometric map**—Map showing relief of any convention, such as contours, hachures, shading, or tinting

p. **Isopleth map**—Map consisting of lines connecting places of equal value of distribution for a given theme such as rainfalls or temperature

q. **Map**—Graphic representation of the earth's surface drawn to scale on a plane surface

r. **Pantograph**—An instrument for copying maps and drawings at a predetermined reduction or enlargement

s. **Planimeter**—A device for measuring small areas by mechanical integration

t. **Planimetry**—Plan detail of a map

u. **Plan view**—A view as seen from directly above the land

v. **Profile**—An outline of a cross section of the earth

w. **Stereoscope**—An optical instrument used for viewing two properly related photographs or diagrams simultaneously to obtain the impression of a 3-dimensional object

x. **Surveying**—Determining and representing accurately on paper the area of any portion of the earth's surface, the lengths and directions of the boundary lines, and the contour of the surface by taking linear and angular measurements, and by applying the principles of geometry and trigonometry

y. **Topography**—The configuration or shape of the land surface of any area

z. **USGS**—United States Geological Survey

Objective 2

Required skills of a civil technician

Note: Civil drafting skills can be acquired from a vocational-technical school or community college that offers a drafting program.

a. Basic drafting techniques in line work, lettering, and the use of tools and equipment

b. Math skills up through trigonometry

c. Good communication skills

d. Recognition of map symbols and abbreviations

e. CAD training: CAM and GIS

f. Map data production and calculations for:
   - Basic surveying
   - Drafting of maps and plans
   - Topographic mapping
   - Cut and fill
   - Digital map files
   - GIS data bases

g. Automated map libraries

h. Understanding of data automation and maintenance

Objective 3

Job responsibilities of a civil technician

Note: These job responsibilities could be assigned to one individual or divided among many different job titles: cartographer, drafter, system manager, programmer, and data base manager.

a. Prepare maps and plans

   Note: To correctly prepare maps and plans, the technician must be able to use reference materials and manuals, drafting equipment, and appropriate symbols and abbreviations, as well as lay out plan sheets and prepare working drawings from sketches and notes.

b. Work with survey data

   Examples: Interpret and reduce field notes, plot contours, lay out bearings and azimuths, lay out boundary surveys and strip surveys

c. Gather, organize, record, and enter data (data base manager)

d. Perform engineering calculations

   Examples: Reduce field notes, calculate traverses, closures, area and volume, horizontal and vertical curves, earthwork volume, horizontal and vertical angles, strengths of material, and state plane coordinates

e. Manage a computer CAD system (systems manager)

f. Compile map data and map production

g. Operate a CAM program

h. Develop CAD software programs

i. Assist in the drafting and design of:
   - Subdivisions
   - Surface drainage systems

- Major structures
- Water treatment facilities
- Water distribution facilities
- Storm sewer systems
- Transportation systems
- Utility facilities
- Structural plans
- Site plans

j. Communicate effectively

Examples: Write reports, work as a team member, lead a work team, prepare graphic exhibits, and present to clients

Objective 4

Major employment opportunities for a civil technician

a. Private civil engineering and surveying firms

Note: Civil engineering and surveying firms are located in every state, and many hire both permanent, full-time civil technicians and freelance civil technicians as well as many other employees.

b. Local government agencies

- County planning offices
- City planning department
- Highway department
- Water department
- Engineering and planning office
- Parks and recreation department

c. Federal government agencies

- Department of Transportation
- Bureau of Census
- Defense Mapping Agency (DMA)
- Department of the Interior

- Department of Agriculture
- Bureau of Indian Affairs
- All energy regulatory agencies
- Corps of Engineers
- Soil Conservation
- Department of Commerce

Note: Other agencies may be available in your area.

Objective 5

Organization structures of design teams in civil engineering firms

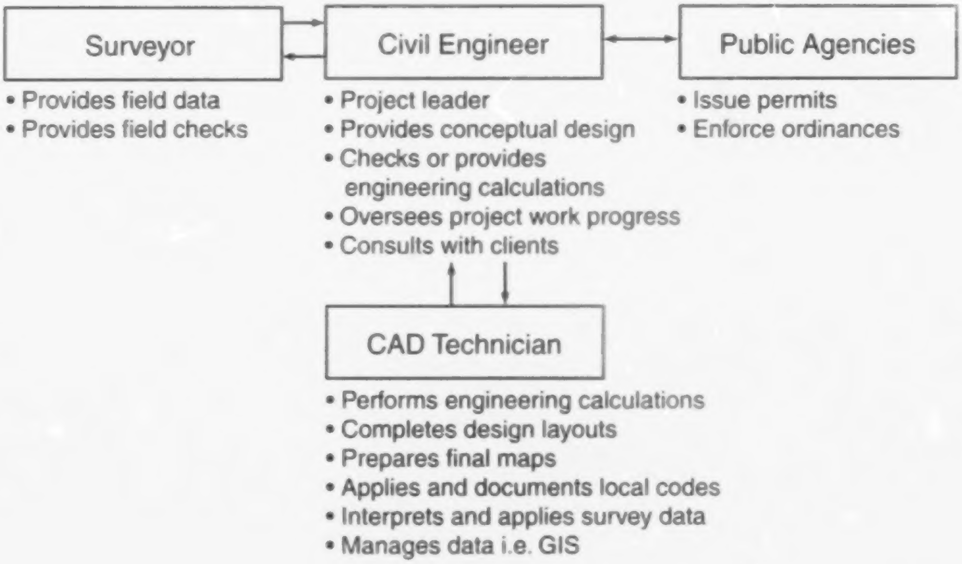
Note: Each firm is unique in the way they organize their line of responsibility.

a. Small civil engineering firms

- Are less structured
- Usually have ten or fewer staff members
- The technician will have many different job responsibilities.
- Communication is usually by word of mouth.

Figure 1

Typical Work Flow and Job Duties (Small Office)


Surveyor
• Provides field data
• Provides field checks
Civil Engineer
• Project leader
• Provides conceptual design
• Checks or provides engineering calculations
• Oversees project work progress
• Consults with clients
Public Agencies
• Issue permits
• Enforce ordinances
CAD Technician
• Performs engineering calculations
• Completes design layouts
• Prepares final maps
• Applies and documents local codes
• Interprets and applies survey data
• Manages data i.e. GIS

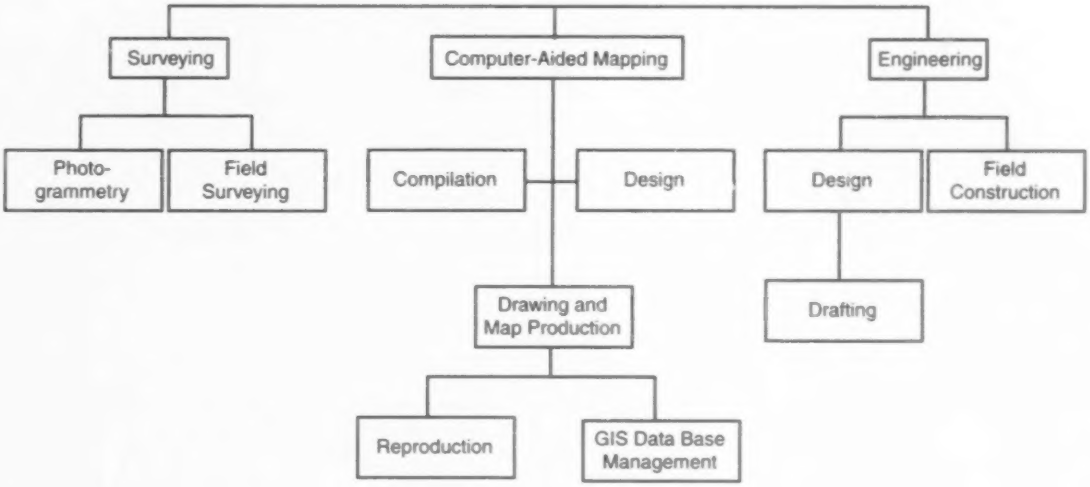
b. Large civil engineering firms

- Have specific lines of authority and responsibility
- Are able to specialize in a specific area

  Examples: GIS data base management, surveying, computer-aided mapping, etc.
- Usually have an organizational/standards manual which will include personnel policies and technical procedures

Figure 2

Typical Organizational Chart (Large Civil Engineering Firm)


Surveying
Computer-Aided Mapping
Engineering
Photo-grammetry
Field Surveying
Compilation
Design
Design
Field Construction
Drawing and Map Production
Drafting
Reproduction
GIS Data Base Management

Objective 6

Specialty areas for civil engineering firms

Note: Some civil engineering firms specialize in only one area, while other larger companies are more diversified and perform work in many of these areas.

a. Land planning and subdivision

b. Transportation

c. Flood control

d. Irrigation and drainage

e. Sewage and water treatment

f. Municipal improvements

g. Environmental studies
h. Land and construction surveys
i. Construction inspection
j. Refuse disposal
k. Map making
l. Power plants
m. Graphic information systems (GIS)
n. Hydrologic studies
o. Foundation work and soil analysis
p. Agribusiness
q. Structural

Objective 7

Occupations related to civil drafting

Note: With additional training and/or experience, a civil technician could move into the following occupations.

a. CAM/CAD technician
b. City planning aide
c. Estimator
d. Civil engineering technician
e. Instrument surveyor's assistant
f. Map maker
g. Planning assistant
h. Surveyor's helper
i. Construction materials testing technician
j. Traffic technician
k. Topographic technician
l. Data base manager
m. Programmer
n. System manager

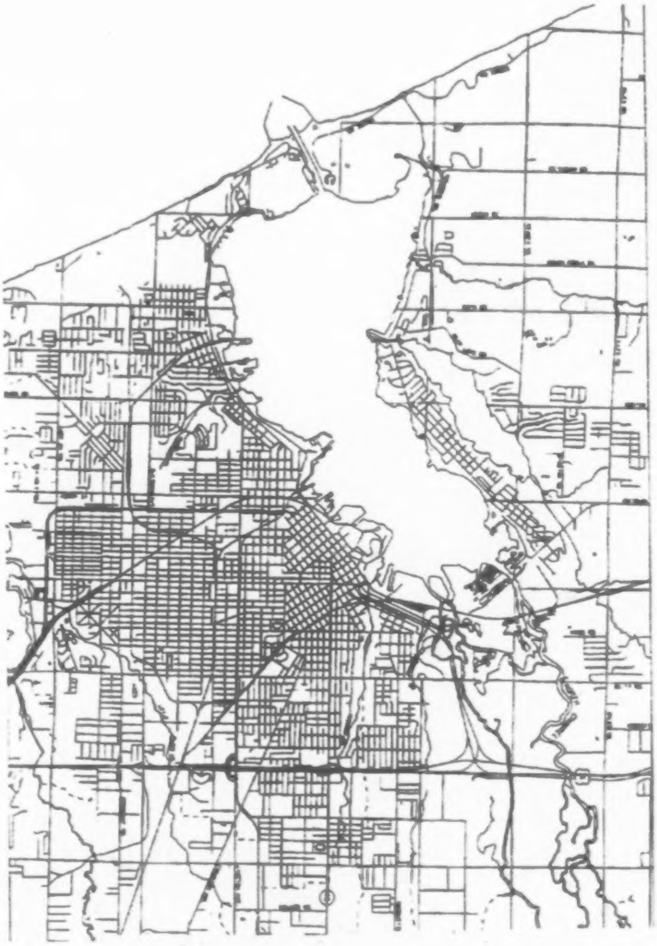
Objective 8

Major types of maps

a. Planimetric maps—Represent only the horizontal positions of features represented, with omission of topographic relief in measurable form

- Base maps—Show information that may be used for purpose of comparison or geographical correlation

  Figure 3

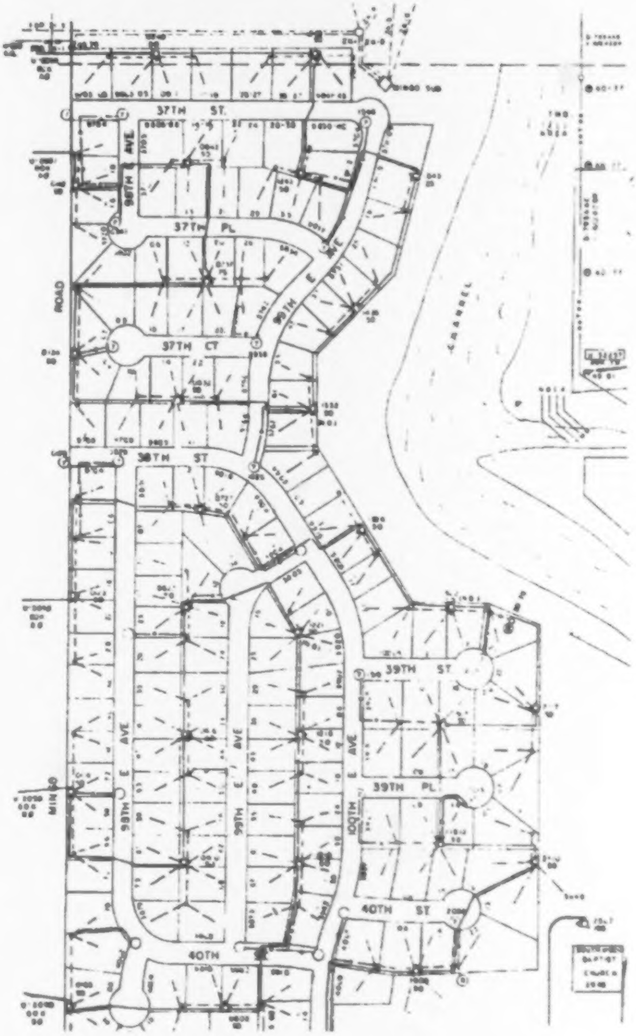


- Line route maps—Road or utility maps

474

- Cadastral maps—Show boundaries of subdivisions of land (i.e. plot) with bearings, lengths, and areas of individual tracts, for purposes of describing and recording ownership

Figure 4


37TH ST.
98TH AVE
37TH PL
ROAD
37TH CT
99TH E AVE
CHANNEL
38TH ST
39TH ST
39TH PL
98TH E AVE
99TH E AVE
100TH E AVE
40TH ST
40TH

- Outline maps—Present only the information needed to provide a basis for compilation of additional data.

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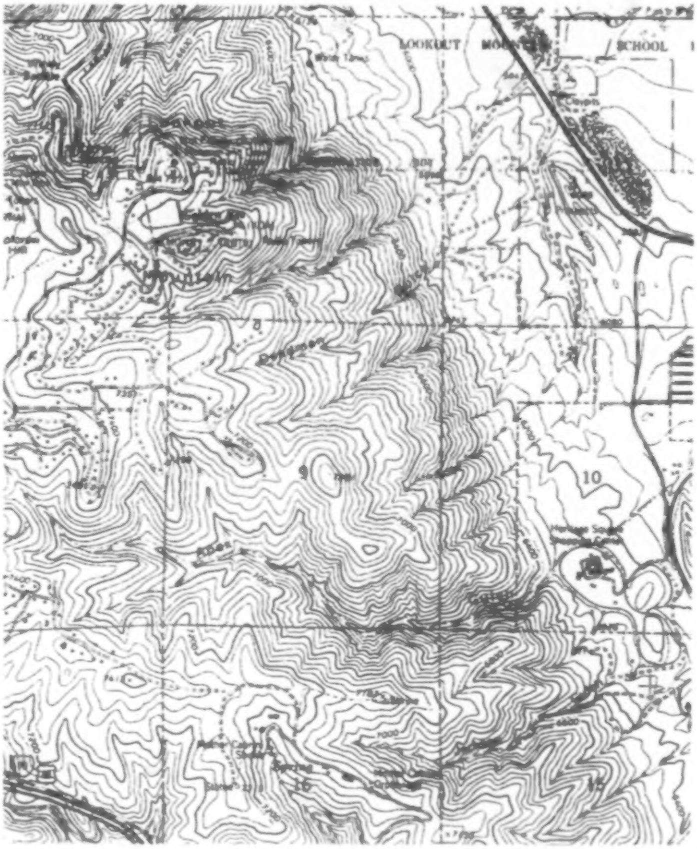
b. Topographic maps—Show positions of features and represent their vertical position in a measurable form

Figure 5



- Contour maps—Most common to represent shape and elevation of the land
- Shaded-relief maps—Pictorial; shaded to simulate sunlight on the terrain
- Slope maps—Show terrain by using a progression of colors or shades to indicate steepness of zones

c. Photoimage maps—Based on aerial photographs; shows more detail not found on conventional maps

- Orthophotoquads—High resolution black and white aerial photos; corrected to eliminate displacement of perspective (Scale-true), derived from a conventional perspective photograph where the terrain relief is removed

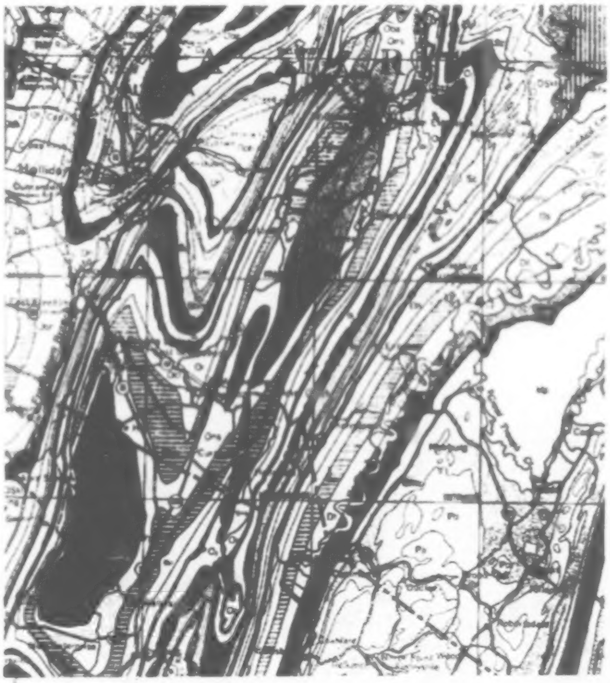
- Orthophotomaps—Refinement of orthophotoquads, which include contour lines and names; color enhanced and related to standard quadrangle formats and reference systems. Map produced by assembling orthophotographs at a specified uniform scale in a map format

  Note: Go to the USGS website to see an example of an orthophotomap.

d. Thematic maps (choropleth map)—Designed to show information about a specific topic such as geology, rainfall, population, in which areas are colored, shaded or hatched to create darker or lighter areas in proportion to the density of distribution of the theme subject

- Two basic types of thematic maps:
  - Choropleth maps—Determine civil boundaries
  - Isopleth maps—Used to show numerical values for continuous distribution (i.e. rainfall)
- Examples of thematic maps:
  - Geologic maps—Show position, structure, and composition of geologic features (Figure 6)
  - Hydrologic maps—Display information about water resources and flood prone zones
  - Land use maps—Display information about how land is being used

Figure 6



e. U.S. Geo Data (digital map data)—Computer tapes/disks that contain cartographic map data in digital form that can be downloaded for use in map preparation

Example: Terrain models

Objective 9

Characteristics of maps

a. Geographic maps

- Show large area of land
- Are drawn to a small scale
- Only show major features such as rivers, lakes, and dots for cities
- Scales vary from a few miles to the inch to several hundred miles to the inch.
- Examples can be found in an atlas.

b. Topographic maps

- Represent surface features of a region
- Large scale maps show all the natural features down to small streams and man-made features such as city streets, bridges, pipelines, etc.
- USGS topographic maps are the most widely known maps in this class.
  - — Are always bounded by meridians of longitude and latitude
  - — Are made to the following scales:

    1:24,000 — 1" = 2000 feet

    1:62,500 — 1" = nearly 1 mile

    1:125,000 — 1" = nearly 2 miles

    1:250,000 — 1" = nearly 4 miles
- Use contour lines to show elevation
- Contour maps showing principally the elevation of the land are used for location, estimating costs, and construction.

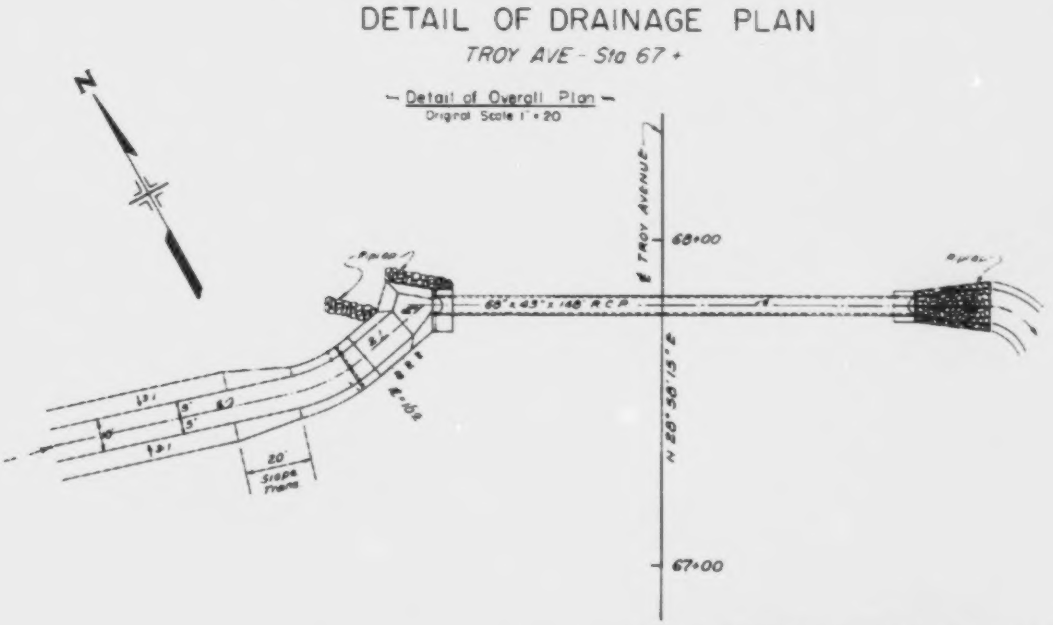
c. Cadastral maps

- Are used primarily for showing political and civil boundaries, property lines, taxation, and transfer of property
- Are considered legal documents
- Are drawn on a large scale—usually greater than 6 inches to a mile

- May contain or show the following:
    - — Property lines—All lengths and bearings of boundary lines
    - — Some natural features to help locate lines on the ground
    - — Acreage
    - — Record of land ownership
    - — Future planning and growth
    - — Location of gas mains, water lines, and sewer lines
- Examples include plats of city additions, mineral rights, and farm surveys.

d. Engineering maps

Figure 7


DETAIL OF DRAINAGE PLAN
TROY AVE - Sta 67 +
N
— Detail of Overall Plan —
Original Scale 1" = 20
℄ TROY AVENUE
68+00
67+00
68" x 43" x 148' RCP
N 20°58'15" E
Riprap
20'
Slope Trans
3'
5'

Courtesy of Colorado Department of Highways

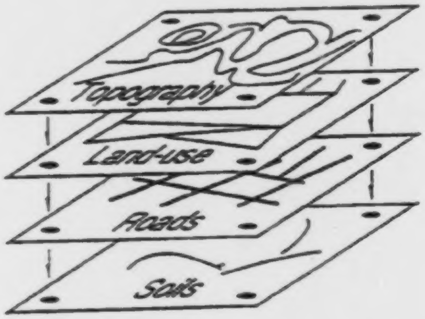
- Are drawn for reconnaissance, construction, or maintenance purposes
- Scale is seldom smaller than 1" = 400 ft and sometimes uses architectural scales.
- May include topographic information
- Can show more detail than a usual topographic map since they are larger in scale
- Examples are maps for railroad, highway, canal, and hydroelectric construction, building site maps, landscape maps, and dam and reservoir maps.

e. Geographic information system (GIS)

Note: Additional information on GIS can be found in Unit 9.

- Automated mapping system linked with a spatial database ("smart map")
- Provides ability to analyze and manipulate data and create new information from this data

Figure 8



Stacked set of map layers where each layer is aligned or registered to other layers. Each layer can contain a unique graphic theme or data type such as shown in this illustration.

Reprinted from the Conservation Technology Information Center's October 1994 newsletter, *Conservation Impact*.

- Builds layers of map information to include:
  - Tax parcels
  - Public utilities
  - Flood plains
  - Railroads
  - School districts
  - etc.

f. Other maps

- Aeronautical charts—Show air traffic routes, radio and electronic aids, obstructions, and elevations of high points
- Hydrographic charts—Show shorelines, water depths, information about harbors, anchorage details, and shipping approaches

  Note: Additional information can be obtained from the National Ocean Survey and the Lake Survey Center.

- Maps based on geodesic data
  - Geodesy is a branch of science and mathematics that determines the exact position of figures, points, and areas along the curvature of the earth.

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— Examples are geologic maps and specialty maps for location sites of minerals and energy sources.

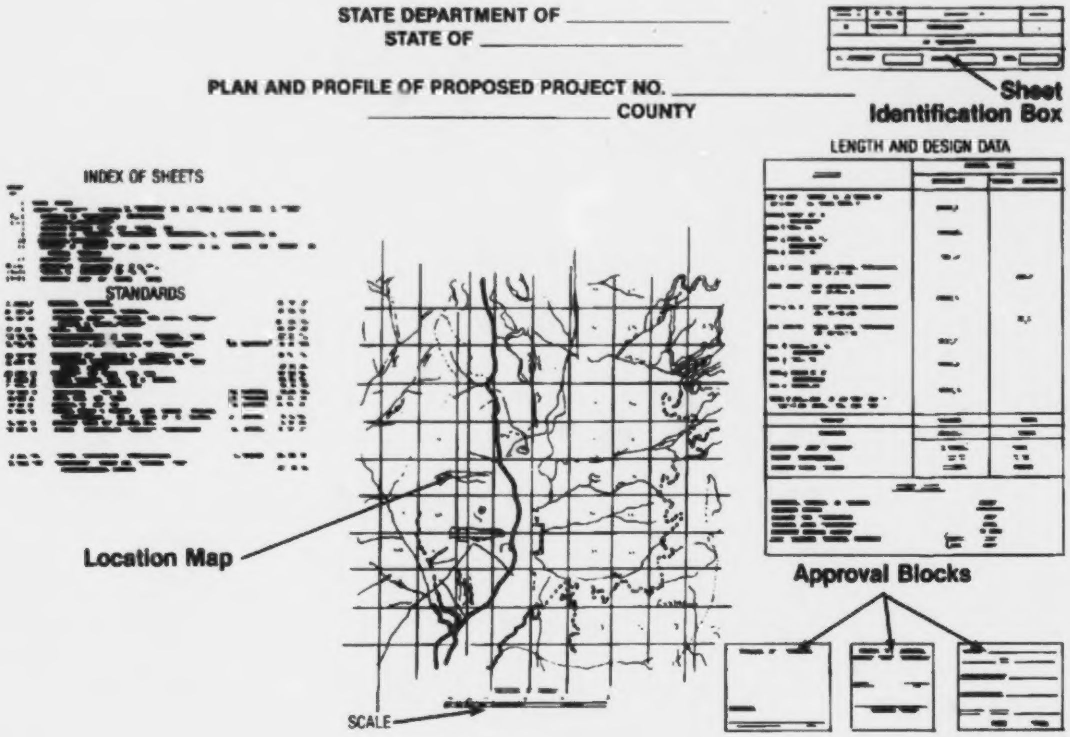
Note: The type of map often correlates to a specific type of survey. Refer to Student Supplement 3 for a chart showing the kinds of surveying and mapping.

Objective 10

Typical drawings used in civil drafting

a. Title sheets (key maps)

Figure 9


STATE DEPARTMENT OF ____________
STATE OF ____________
PLAN AND PROFILE OF PROPOSED PROJECT NO. ____________
____________ COUNTY
Sheet Identification Box
LENGTH AND DESIGN DATA
INDEX OF SHEETS
STANDARDS
Location Map
SCALE
Approval Blocks

- Identify the project with a name and number
- Show location map of the project
- Give an index to all sheets in the plan set

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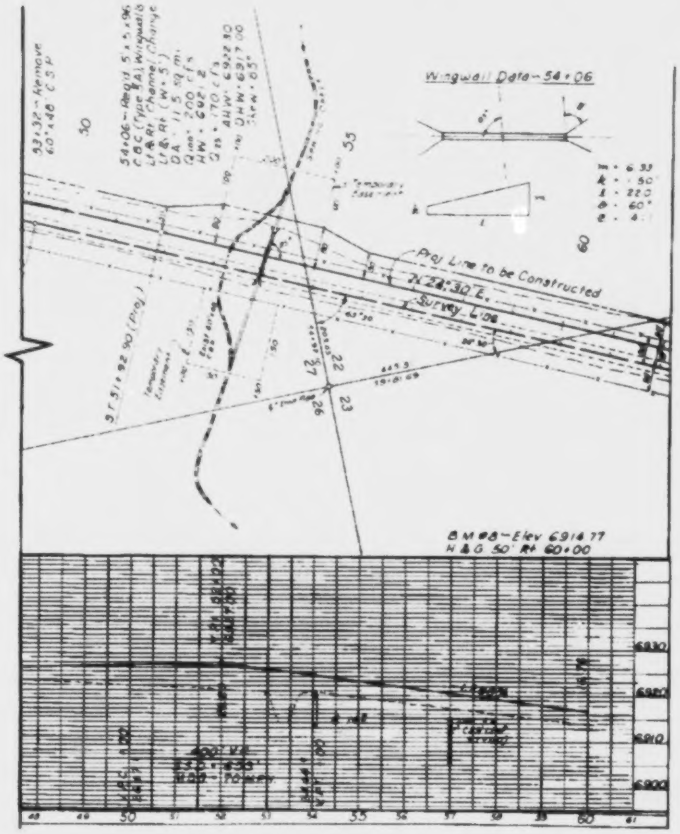
b. Plan and profiles—Are drawings composed of a plan view and profile view (usually located directly below the plan)

Note: The plan and profile as used by civil engineers and state highway departments can be compared to a top and section view in mechanical drafting.

Figure 10


53+32 – Remove
60"×48" C S P
50
54+06 – Req'd 5 × 5 × 96
CBC (Type A) Wingwalls
Lt & Rt Channel Change
Lt & Rt (W = 5')
DA = 11.5 sq mi
HW = 602 .2
AHW = 6922.10
OHW = 6917.00
Skew = 65°
55
Temporary Easement
Wingwall Data – 54 + 06
m = 6.33
k = 50
l = 22.0
θ = 60°
e = 4:1
60
Proj Line to be Constructed
N 24°30' E
Survey Line
S.T. 51 + 92.90 (Proj.)
Temporary Easement
27
22
26
23
BM #8 – Elev 6914.77
H & G 50' Rt 60+00
400' V.C.
6930
6920
6910
6900
48
49
50
51
52
53
54
55
56
57
58
59
60
61

Courtesy of Colorado Department of Highways

c. Typical cross sections

- Are views of the inside of the project cut open at right angles to the survey centerline
- Types of cross sections
  - — Natural ground cross section
  - — Typical section

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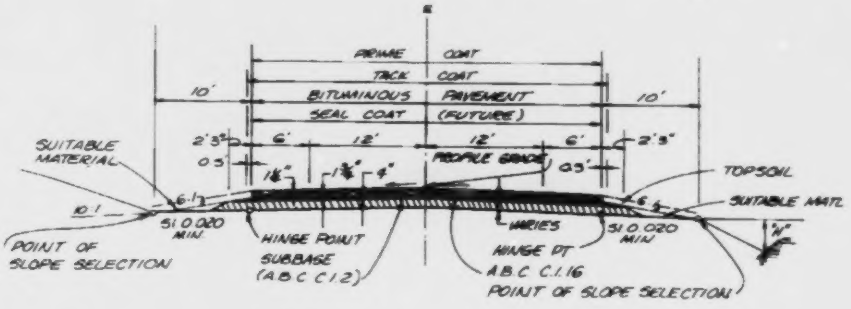
— Roadway cross section

Figure 11

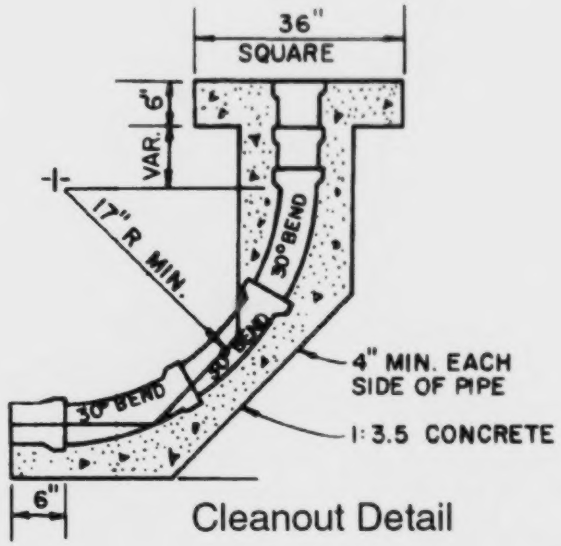

PRIME COAT
TACK COAT
BITUMINOUS PAVEMENT
SEAL COAT (FUTURE)
10'
10'
2'3"
6'
12'
12'
6'
2'3"
0.5'
0.5'
PROFILE GRADE
1½"
1½"
4"
SUITABLE MATERIAL
10:1
6:1
6:1
Sl 0.020 MIN
Sl 0.020 MIN
TOPSOIL
SUITABLE MATL
VARIES
"H"
POINT OF SLOPE SELECTION
HINGE POINT
SUBBASE (A.B.C C1.2)
HINGE PT
A.B.C C1.16
POINT OF SLOPE SELECTION

Courtesy of Colorado Department of Highways

— Cut and fill cross section

d. Structural details

Figure 12


36"
SQUARE
6"
VAR.
17" R MIN.
30° BEND
30° BEND
30° BEND
4" MIN. EACH SIDE OF PIPE
1:3.5 CONCRETE
6"
Cleanout Detail

- Provide a close-up look at how a particular structural component is made
- Show materials, dimensions, and section where needed

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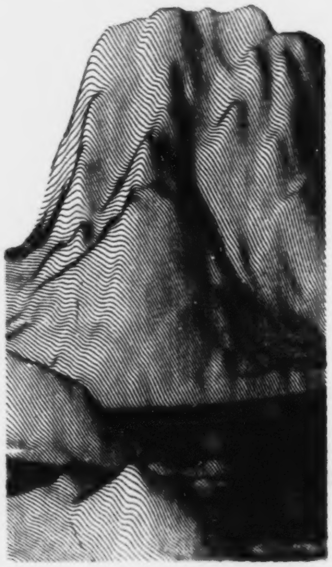
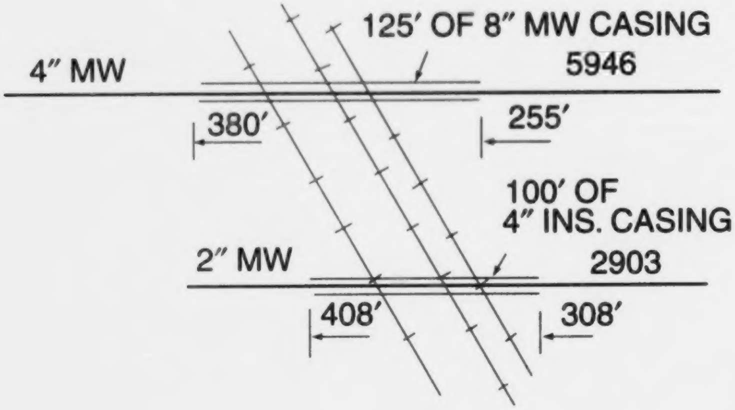
e. Pictorial drawings—Provide the viewer a three-dimensional view of the map area

Figure 13



f. Schematic diagrams—Are details that may show connections and flow directions through the use of symbols, lines, and dimensions

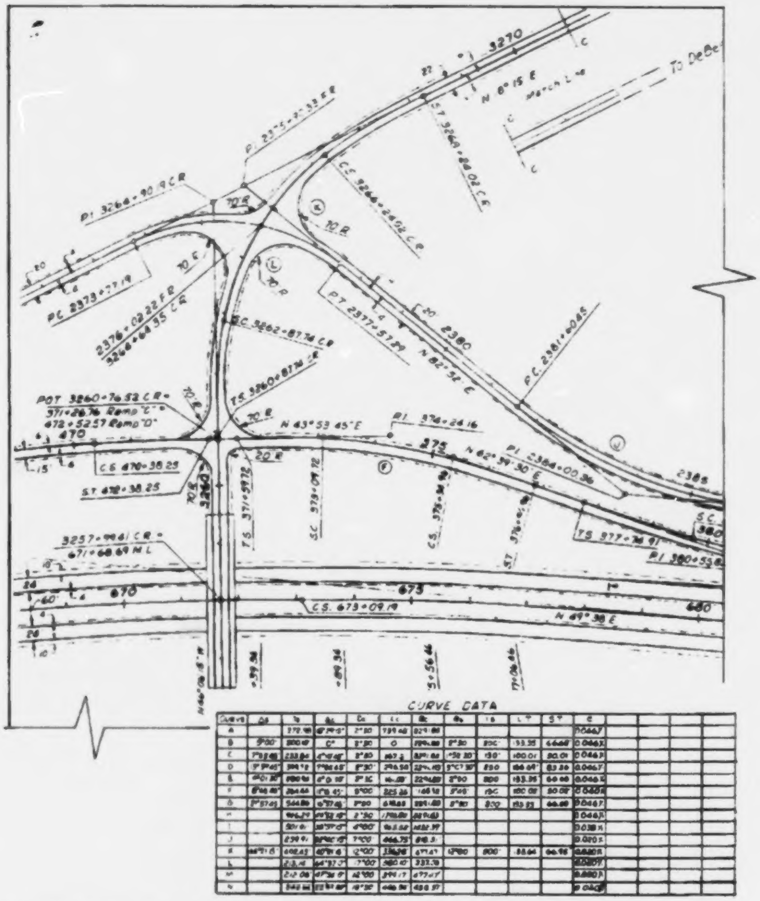
Figure 14


125′ OF 8″ MW CASING
5946
4″ MW
380′
255′
100′ OF
4″ INS. CASING
2″ MW
2903
408′
308′

484

g. Intersection details—Are enlarged drawings of an intersection of several streets that come together; show all pertinent information such as dimensions, right-of-ways, centerlines, and curve data

Figure 15


3270
N 6°15' E
To DeBe
3264+90.19 C.R.
PC 2373+77.19
PT 2377+57.29
2380
PC 2381+00
POT 3260+76.52 C.R.
N 43°53'45" E
PI 374+24.16
470
CS 470+38.25
ST 472+38.25
3257+99.61 C.R.
671+68.69 M.L.
670
675
680
CS 673+09.19
N 49°38' E
CURVE DATA

Courtesy of Colorado Department of Highways

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Information Sheet

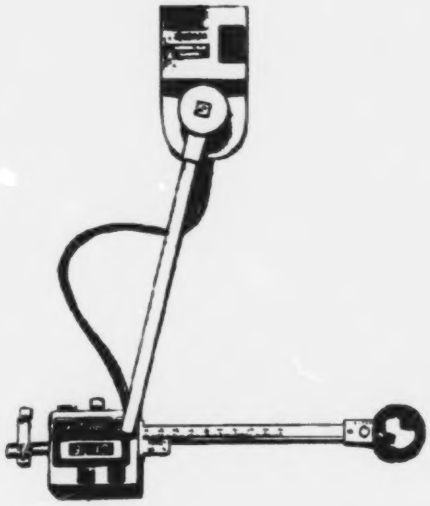
Objective 11

Drafting equipment used by civil technicians

Note: Most engineering offices use the same basic drafting tools. In this unit, only specific tools used by civil technicians will be covered. Refer to MAVCC's publication, *Basic Drafting*, for basic drafting tools. The tools listed below are quickly being replaced with CAD software but are still shown here because some firms use them as needed.

a. Electronic planimeter

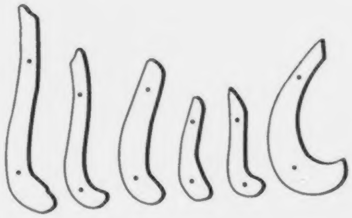
Figure 16



b. Curves

- Ship curves

Figure 17

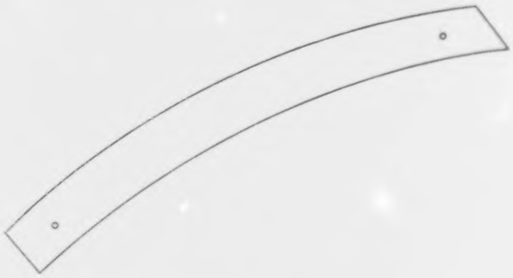


486

- Flexible rule curves
- Highway radius curves

Note: Various radii (3″–200″) are available.

Figure 18

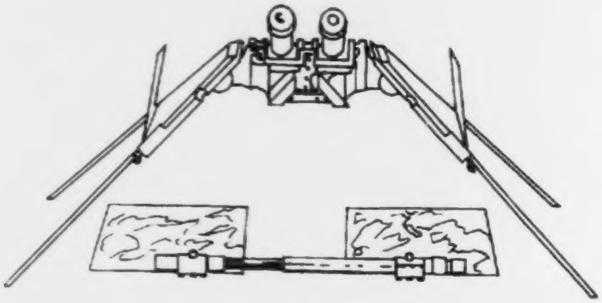


- Railroad curves

Note: Various degrees of curvature (0°15′–20°) are available.

c. Stereoscope

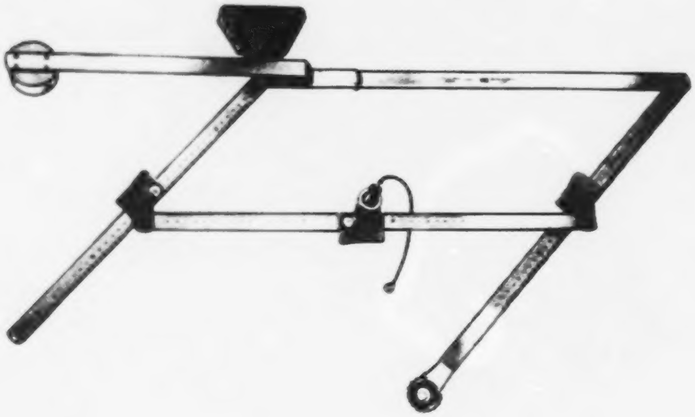
Figure 19



d. Other specialty tools

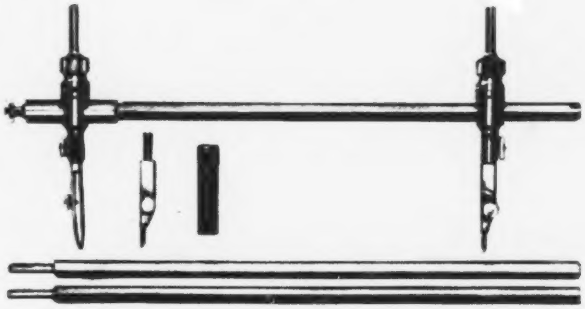
- Pantograph

  Figure 20



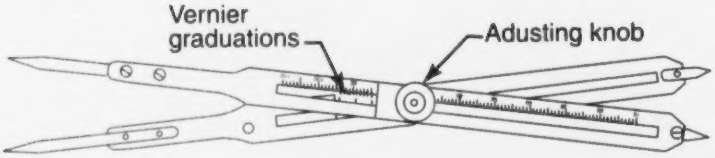
- Beam compass

  Figure 21



- Proportional divider

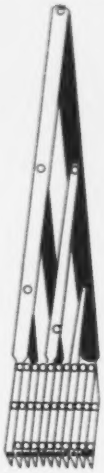
  Figure 22


Vernier graduations
Adusting knob

488

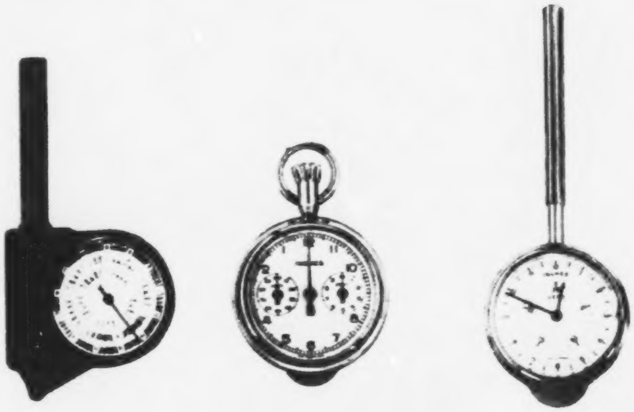
- Spacing divider

  Figure 23



- Map measures

  Figure 24



Student Supplement 1—Math Assessment

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completed all problems and showed work	______
• Answered at least 85% for each part correctly	______

Basic Skill

Mathematics

Directions

The following problems are designed to assess your basic math skills in various areas. Solve each problem and place your answer in the blank or space allowed.

PART A: Converting fractions

1. Convert each of the following mixed numbers to improper fractions (where the numerator is the same or larger than the denominator such as $\frac{4}{4}$, $\frac{5}{3}$, and $\frac{10}{9}$.) **Do not** reduce answers to lowest terms at this time.

a. $3\frac{1}{4}$ = ________

b. $4\frac{1}{2}$ = ________

c. $7\frac{1}{3}$ = ________

d. $8\frac{1}{2}$ = ________

e. $6\frac{2}{3}$ = ________

f. $2\frac{1}{2}$ = ________

g. $3\frac{2}{4}$ = ________

h. $7\frac{3}{4}$ = ________

i. $9\frac{2}{3}$ = ________

j. $5\frac{2}{3}$ = ________

2. Convert each of the following improper fractions to mixed numbers. **Do not** reduce answers to lowest terms at this time.

a. $\frac{16}{5}$ = ________

b. $\frac{12}{5}$ = ________

c. $\frac{17}{3}$ = ________

d. $\frac{8}{3}$ = ________

e. $\frac{9}{2}$ = ________

f. $\frac{19}{13}$ = ________

g. $\frac{8}{7}$ = ________

h. $\frac{75}{32}$ = ________

i. $\frac{24}{13}$ = ________

j. $\frac{13}{9}$ = ________

Student Supplement 1

PART B: Reducing fractions to lowest terms

Reduce the following fractions to the lowest terms.

1. $\frac{3}{9} =$ ____________
2. $\frac{8}{24} =$ ____________
3. $\frac{10}{15} =$ ____________
4. $\frac{15}{25} =$ ____________
5. $\frac{12}{48} =$ ____________
6. $\frac{5}{5} =$ ____________
7. $\frac{8}{12} =$ ____________
8. $\frac{7}{21} =$ ____________
9. $\frac{4}{8} =$ ____________
10. $\frac{10}{12} =$ ____________

PART C: Finding lowest common denominators (LCD)

Find the lowest common denominator and convert each fraction to its LCD equivalent.

1. a. $\frac{2}{3}, \frac{7}{9}$ LCD = ______________
   b. $\frac{2}{3} =$ __________
   c. $\frac{7}{9} =$ __________
2. a. $\frac{7}{8}, \frac{5}{6}$ LCD = ______________
   b. $\frac{7}{8} =$ __________
   c. $\frac{5}{6} =$ __________
3. a. $\frac{1}{3}, \frac{11}{12}, \frac{3}{8}$ LCD = ______________
   b. $\frac{1}{3} =$ __________
   c. $\frac{11}{12} =$ __________
   d. $\frac{3}{8} =$ __________
4. a. $\frac{1}{7}, \frac{5}{8}$ LCD = ______________
   b. $\frac{1}{7} =$ __________
   c. $\frac{5}{8} =$ __________
5. a. $\frac{1}{16}, \frac{3}{8}, \frac{3}{4}$ LCD = ______________
   b. $\frac{1}{16} =$ __________
   c. $\frac{3}{8} =$ __________
   d. $\frac{3}{4} =$ __________

PART D: Adding, subtracting, multiplying, and dividing fractions

1. $\frac{7}{12} + \frac{5}{8} =$ ____________________
2. $\frac{3}{5} + \frac{2}{3} =$ ____________________
3. $\frac{1}{16} + \frac{3}{8} + \frac{3}{4} =$ ____________
4. $\frac{3}{20} + \frac{3}{4} + \frac{7}{10} + \frac{4}{5} =$ ________
5. $\frac{7}{8} - \frac{2}{3} =$ ____________________
6. $\frac{4}{5} - \frac{3}{8} =$ ____________________
7. $\frac{5}{9} - \frac{3}{8} =$ ____________________
8. $\frac{1}{3} - \frac{5}{16} =$ ____________________
9. $1\frac{1}{2} \times 2\frac{1}{4} =$ ______________
10. $\frac{1}{2} \times 6\frac{1}{2} =$ ______________
11. $\frac{7}{8} \times \frac{2}{3} =$ ______________
12. $\frac{1}{4} \times \frac{1}{3} \times \frac{1}{2} =$ ______________
13. $\frac{3}{8} \div \frac{1}{2} =$ ______________
14. $8 \div \frac{3}{5} =$ ______________
15. $12\frac{3}{8} \div 1\frac{1}{2} =$ ____________

PART E: Converting fractions to decimals

1. $5\frac{6}{10} =$ __________________
2. $1\frac{2}{100} =$ __________________
3. $\frac{87}{1000} =$ __________________
4. $7\frac{83}{1000} =$ ______________
5. $5\frac{6}{1000} =$ ______________
6. $3\frac{3}{4} =$ ____________________
7. $55\frac{1}{2} =$ ______________
8. $110\frac{5}{8} =$ ______________
9. $77\frac{1}{50} =$ ______________
10. $12\frac{2}{3} =$ ______________

PART F: Adding, subtracting, multiplying, and dividing decimals

1.
$$\begin{array}{r} 5.29 \\ 4.38 \\ +\ \underline{9.62} \end{array}$$

2.
$$\begin{array}{r} 72.24 \\ 16.38 \\ +\ \underline{92.37} \end{array}$$

3. 868.87– 516.89 = ______
4. \$15 - \$12.53 = ________
5. 2.54 x 3.1 = __________
6. 35 x 8.5 = ____________
7. 120 x 0.33 = __________
8. 26.4 x 3.8 = ____________
9. 10.71 ÷ 0.07 = __________
10. 0.225 ÷ 0.15 = __________

PART G: Converting fractions to percentages

1. $\frac{1}{4}$ = ____________
2. $\frac{2}{9}$ = ____________
3. $\frac{7}{10}$ = ____________
4. $\frac{3}{4}$ = ____________
5. $\frac{2}{2}$ = ____________

PART H: Percentage problems

1. There are 100 spot elevations on the map. Twenty-five spot elevations are what percent of the spot elevations on the map?

   ____

2. If 11% of the employees are field technicians, what percent work only in the office?

   ____

3. There are 20 employees in a civil engineering office. Sixty percent of the employees have degrees. How many are degreed employees?

   ____

4. One day 5% of the 20 operators in Mr. Moore's group made perfect time completing a job. How many operators made perfect time?

   ____

5. Contractor McGill bought a new compressor, regularly selling for $120, at a sale and saved 20%. What was the sale price?

   ____

PART I: Mix ratio problems

1. Given 90 cu. yd. of aggregate, how much sand will you need to mix a 3:2 ratio of sand and aggregate?

   ________________cu. yd. of sand

2. You are to mix 1/4" aggregate and 1/2" aggregate to a ratio of 3:2. How much 1/4" aggregate will you need if you have 150 cu. yd. of 1/2" aggregate?

   ________________cu. yd. of 1/4" aggregate

3. Given 300 gallons of asphalt concrete, mix asphalt concrete and solvent to a ratio of 75:25. How much solvent will you need?

   ________________gal. of solvent

4. The fuel mixture ratio of gasoline to two-cycle engine oil is 20:1 for your chain saw. How much oil will you add to 5 gallons of gas?

   ________________qt. of oil

5. The ratio of an industrial strength cleaner in water is 6 parts cleaner to 100 parts water. You estimate the job will take 15 gallons of water. How much cleaner will you add?

   ________________gal. cleaner

PART J: Slope ratio problems

1. Find the slope ratio in feet and in inches. Convert distances to like terms where needed. Round off to the nearest hundredth.

   V = vertical distance
   H = horizontal distance

	DISTANCES	RATIO (FEET)	RATIO (INCHES)	SLOPE RATIO
a.	V=12 ft. H=24 ft.	________	________	________
b.	H=15 in. V=5 in.	________	________	________
c.	H=5 ft. V=0.05 ft.	________	________	________
d.	V=1 in. H=3 ft.	________	________	________
e.	H=12ft. V=4 in.	________	________	________

2. Find the vertical distance.

	SLOPE RATIO	HORIZONTAL DISTANCE	VERTICAL DISTANCE
a.	3:1	24 ft.	__________ft.
b.	14:1	224 in.	__________in.

3. Find the horizontal distance.

	SLOPE RATIO	VERTICAL DISTANCE	HORIZONTAL DISTANCE
a.	25:1	0.5 ft.	__________ft.
b.	16:3	9 in.	__________ft.
c.	40:1	4 ft.	__________ft.

Student Supplement 1

PART K: Measure and volume

1. Conversions. Round answers to nearest tenth.

   a. 48 in.= ________ft.

   b. 312 ft.= ________yd.

   c. 8 cu. yd.= __________cu.ft.

   d. 7 sq. yd.= __________sq.ft.

   e. 11 gal.= ________qt.

2. Basic formulas for areas and volumes

   a. 24′ long, 18′ wide—Surface area = ____________

   b. 13″ wide, $2\frac{1}{2}'$ long—Surface area= ____________

   c. 7′ long, 2′ wide, 1′ high—Volume= ______________

   d. $\frac{1}{2}'$ wide, 3″ high, 2′ long—Volume= ______________

   e. 4″ long, 2″ wide, $\frac{1}{2}''$ high—Volume= ____________

3. Word problems. Round off answers to the nearest tenth. Show your work.

   a. One cubic yard of aggregate weighs 2,550 lb. How many tons would 10 cubic yards weigh?

      (Note: 1 ton=2,000 lb.)

      __________________tons

   b. What is the surface area of a failure 2 ft. 8 in. by 1 ft. 6 in.?

      __________________sq. ft.

   c. How many cubic feet of concrete will be required to make a pavement patch 8 feet long, 7 feet wide, and 6 inches deep?

      __________________cu. ft.

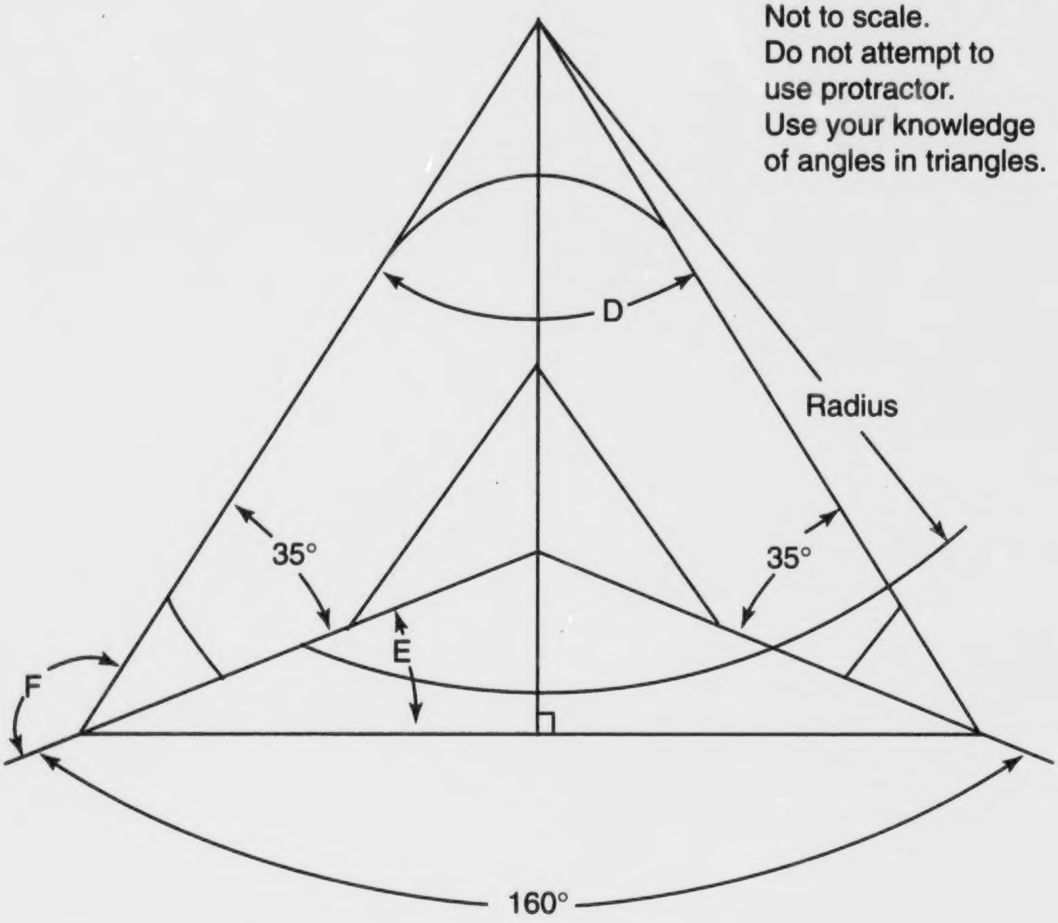
   d. How many square feet have to be painted on a building 20 feet long on each side and 14 feet high if you paint all four sides? If a gallon of paint covers 350 square feet, how many gallons are required?

      __________________sq. ft.

      __________________gal. of paint

PART L: Measuring angles

1.

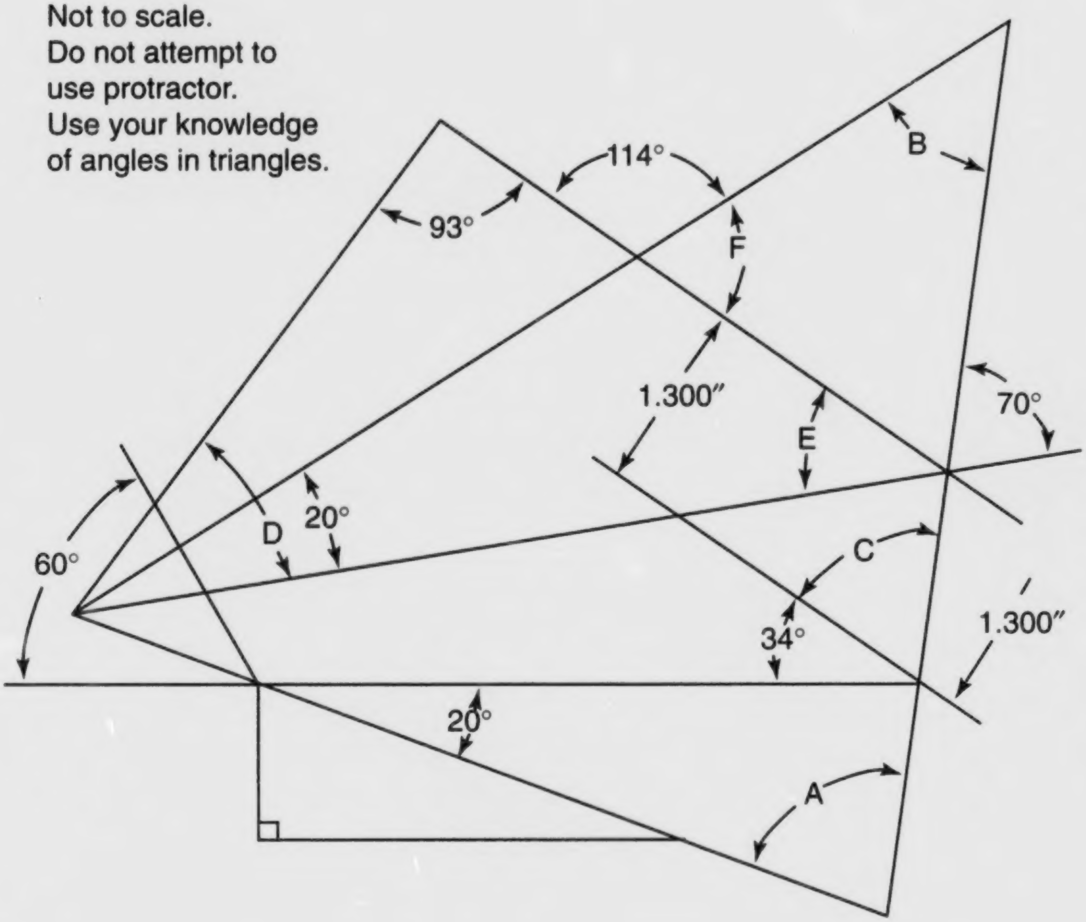


Not to scale.
Do not attempt to use protractor.
Use your knowledge of angles in triangles.

a. Determine D ________
b. Determine E ________
c. Determine F ________

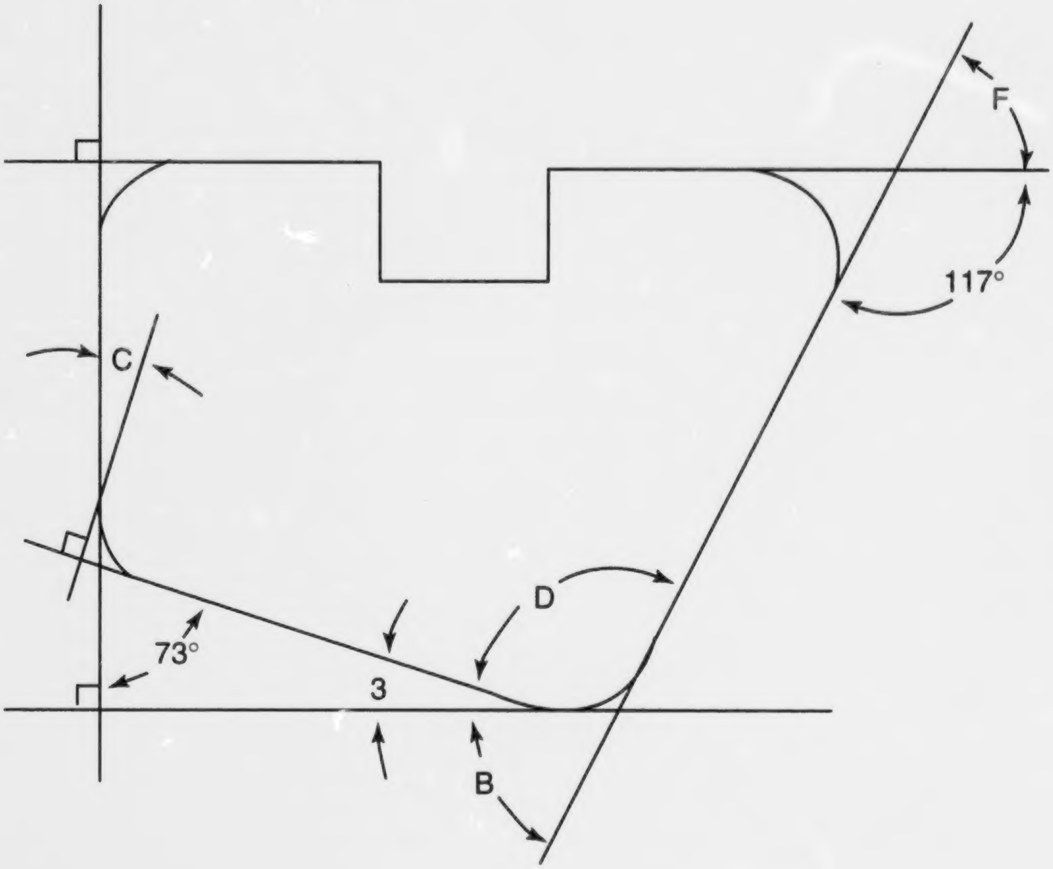
2.

Not to scale.
Do not attempt to
use protractor.
Use your knowledge
of angles in triangles.


114°
B
93°
F
1.300″
70°
E
60°
D
20°
C
34°
1.300″
20°
A

a. Determine D __________
b. Determine E __________
c. Determine F __________
d. Determine B __________
e. Determine C __________
f. Determine A __________

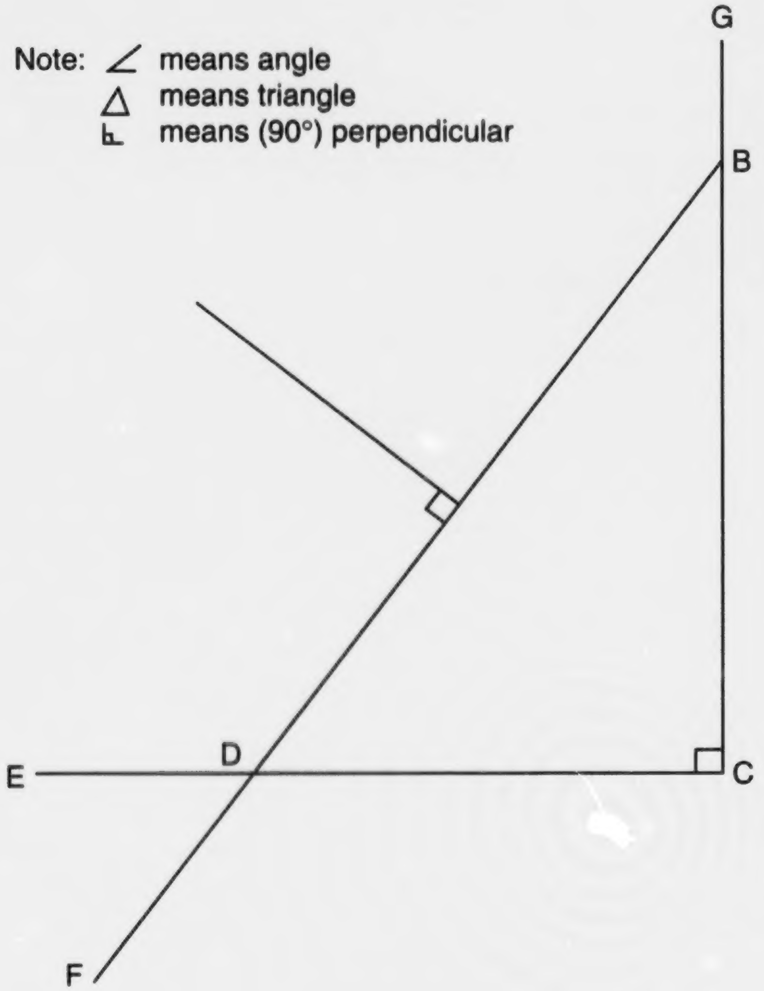
3.



a. Determine D ________
b. Determine E ________
c. Determine F ________
d. Determine B ________
e. Determine C ________

4.

Note: ∠ means angle
△ means triangle
⊾ means (90°) perpendicular



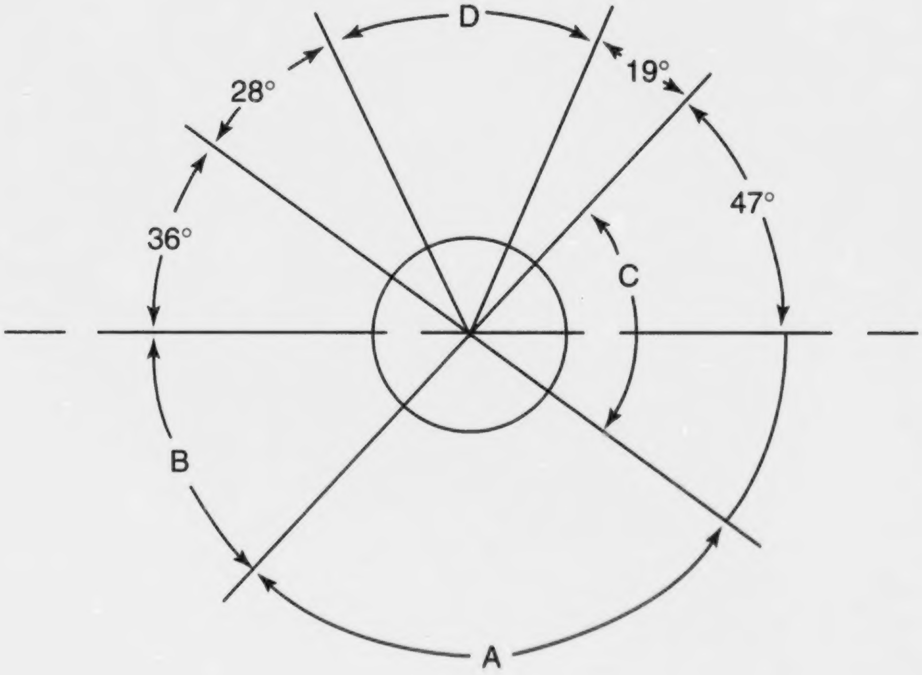
a. Determine ∠BDC in right △ BCD if ∠DBC = 38° ______

b. Determine ∠BDE ________

c. Determine ∠EDF ________

d. Determine ∠DBG ________

5.



a. Determine D ________________

b. Determine A ________________

c. Determine C ________________

d. Determine B ________________

e. What is the complement of D?________________

f. What is the supplement of A? ________________

g. What is the complement of C?________________

h. What is the complement of B?________________

Student Supplement 2—Map Products and Sources

Products	*Producing agency*	*Available from*
Aeronautical charts	NOS	NOS
Boundary information:		
United States and Canada	IBC	IBC
United States and Mexico	IBWC	IBWC
Boundary and annexation surveys of incorporated places with 2,500 or more inhabitants	BC	GPO
Civil subdivisions and reservations	BLM	BLM
State/Federal	DOS	DOS
Census data (social and economic)	BC	GPO
Climactic maps	NWS	NWS
Earthquake hazard maps	USGS	USGS
Federal property maps:		
Water and Power Resources Service	WPRS	WPRS
Fish and Wildlife Service	FWS	FWS
National Aeronautics and Space Administration	NASA	NASA
National forests	FS	FS
National Park Service	NPS	NPS
Military reservations:		
Air Force	USAF	USAF
Army	USA	USA
Coast Guard	USCG	USCG
Marines	USMC	USMC
Navy	USN	USN
State maps of lands administered by Bureau of Land Management	BLM	BLM
U.S. maps of lands administered by Bureau of Land Management	BLM	BLM
Flood-plain maps	DRBC FIA MRC NOS SCS USCE USGS	DRBC FIA MRC FIA SCS USCE USGS
Geodetic control data	NOS USCE USGS	NOS USCE NOS/NCIC
Geologic maps:		
Coal investigations	USGS	USGS
General geologic	SGA USGS	SGA USGS
Geophysical investigations	NOAA NOAA USGS	EDIS ERL USGS
Mineral investigations	USGS	USGS
Mines	BM	BM
Oil and gas investigations	USGS	USGS
Geographic maps:	NOS	NOS
Land use	USGS	USGS

Products	*Producing agency*	*Available from*
Highway maps:		
Indian lands	BIA	BIA
Federal lands	FHWA	FHWA
Federally funded roads	FHWA	GPO
Federal primary and secondary	FHWA	GPO
Interstate	FHWA	FHWA
Federal highway maps of the U.S.	FHWA	GPO
Historical maps and charts	LC All federal agencies	LC NARS
Hydrographic charts & bathymetric maps:	NOS USCE USGS	NOS USCE USGS
Hydrographic surveys	NOS USGS	NOS USGS
Nautical charts	NOS USCE	NOS USCE
Navigable waterways maps	USCE	USCE
River and stream surveys	MRC	MRC
River basin/watershed studies	ERC SCS USGS	ERC SCS USGS
River surveys	WPRS USGS	WPRS USGS
Wildlife and scenic river jurisdiction	BLM	BLM
Hydrologic investigations atlases	USGS	USGS
Indian reservations:		
Land surveys	BIA	GPO
U.S. maps of Indian lands	BIA	GPO
Land plats	BLM BLM NPS USCE	BLM NARS NPS USCE
National Atlas of the U.S.	USGS	USGS
Photographic products:		
Aerial photographs	ASCS BLM BLM BPA DMA NASA FHWA FS FS FWS FWS NOS NPS SCS USCE FS USGS	ASCS BLM EDC BPA DMA EDC FHWA EDC NCIC EDC NCIC NOS NPS SCS USCE FS NCIC/EDC

Student Supplement 2

Products	*Producing agency*	*Available from*
Orthophotomaps	BIA	BIA
	NOS	NOS
	USGS	USGS
Space imagery:		
Landsat (ERTS)	NASA	ASCS
	NASA	EDC
	NASA	EDIS
NASA manned spacecraft	NASA	EDC
Nimbus	NWS	NWS
Skylab	NASA	ASCS
	NASA	EDC
Tiros	NWS	NWS
Recreation maps	BLM	BLM
	HCRC	HCRC
Seismicity maps and charts	ERL	ERL
	USGS	USGS
Soils	SCS	SCS
Soils—substation quality	BPA	BPA
Topographic maps	USGS	USGS
	MRC	MRC
	NASA	NASA
Utilities:		
Ground conductivity maps of the U.S.	FCC	GPO
Principal electric-facilities maps of the U.S.	ERC	GPO
Principal natural-gas-pipelines maps of the U.S.	ERC	GPO
Water resources development data	USGS	USGS
Miscellaneous data:		
Clinometric (slope) maps	USGS	USGS
Gravity survey charts	EDIS	EDIS
	NOS	NOS
	USGS	USGS
Income distribution maps	BC	GPO
Isogonic charts	USGS	USGS
Isomagnetic charts	NOS	NOS
Magnetic charts	EDIS	EDIS
National science trail maps	SCS	SCS
State indexes of fish hatcheries and national wildlife refuges	FWS	FWS
Storm evacuation maps	NOS	NOS
Tree danger (to powerlines) detection maps	BPA	BPA
U.S. location maps of fish hatcheries and national wildlife refuges	FWS	FWS

Student Supplement 3—Types of Surveying and Mapping

Land or Property Surveying (Cadastral)

- Property and boundary surveys
- Subdivision surveys and plats
- Public-lands surveys
- Surveys for plans and plats
- Annex

Engineering Surveys for Design and Construction

- Design data surveys (including route surveys)
- Construction surveys
- Mine surveys

Geodetic Surveying, Geodetic Engineering, or Geodesy

- Control surveys, first- and second-order accuracy
- Geodetic astronomy
- Gravity surveys, magnetic declination surveys, figure-of-the-earth studies

Cartographic Surveying, Cartographic Engineering, or Map and Chart Surveying

- Control surveys, third- and fourth-order accuracy
- Topographic-planimetric surveys and maps
- Hydrographic surveys

Aerial Survey Series

- Aerial photography
- Electrical measurements for distances and position fixes
- Airborne magnetometer surveys
- Radar-altimeter profiles and elevation

Cartography (Not Requiring Original Surveys)

- Map design
- Compilation derived from existing source data
- Map editing
- Map reproduction

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Student Supplement 4—Internet Addresses for Mapping Resources

Digital Elevation Models: http://rmmcweb.cr.usgs.gov/elevation/dpi_dem.html#obtain

USGS (United States Geological Survey):
- <URL: http://www.usgs.gov/>http://h2o.usgs.gov/public/wid/index-state.html
- Provides a list of digital products available through the USGS

Defense Mapping School: http://164.214.2.53/information/DMS/survey.html

U.S. Geological Survey—Rocky Mountain Mapping Center:
- http://rmmcweb.cr.usgs.gov/public/rockylink_top.html

SDTS Spatial Data Transfer Standard:
- Internet Address—Sdts.er.usgs.gov
- User I.D.—Anonymous
- Password—(your Internet address)
- After connecting—cd pub/sdts
- Developed by federal agencies to share spatial data among projects that use different hardware, software and operating systems; 1992

Software—Civil Applications
- Eagle Point Homepage URL: http://www.eaglepoint.com
- Softdesk: http://www.softdesk.com/civil/civil.htm

GIS
- Autodesk—Mapguide technology: http://www.mapguide.com
- Provides a client/server framework to access GIS technology
- www.gis-solutions.com
- www.gis.com

GPS
- email: mggpsworld@acol.com
- Anderson & Associates: http://www.andassoc.com/gps.html
  email: anderson@andassoc.com

Other
- www.whitepages.com.au
- www.pmel.noaa.gov/vents/coax/gis_www.html
- www.erda.com/mapsheets
- www.eaglemap.com
- www.datamocracy.com
- www.Topcon.com

Objective 12

Assignment Sheet 1—Interview a Civil Technician

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Answers are clear and concise	______
• Assignment is neat and legible	______

Basic Skills

Reading Writing Oral Communication Employability Critical Thinking

Note: Complete this assignment after consulting with your instructor.

Directions

Make an appointment with a civil technician who is presently employed in that capacity. Ask the following questions and record the answers in the blanks provided.

1. What is your career title? ______________________
2. What tasks do you perform on the job? ______________________
3. What educational training and occupational experience is required for this job? ______________________
4. What personality traits are most important in your field? ______________________
5. What skills and knowledge are required in this occupation? ______________________

6. What is the approximate starting salary of workers in your corporation?

7. What is the employment outlook for the future in this career?

8. What are the possibilities for advancement in this field?

9. What is your favorite part of this job?

10. What is your least favorite part of this job?

11. Which CAD software does your company use?

12. Do you do field work? If so, please describe your job duties.

13. Does your company do hand drafting of maps and documents?

14. Describe a typical day on the job.

Objective 13

Assignment Sheet 2—Research Possible Employment Opportunities in Civil Drafting Technology in Your Local Area

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Answers are clear and concise	______
• Assignment is neat and legible	______

Basic Skills

Reading Writing Oral Communication Employability Critical Thinking

Note: Complete this assignment after consulting with your instructor.

Directions

Provide the information requested for each of the items listed below.

1. List the names of firms in your area that may employ civil technicians.

   Note: Include address and phone numbers for future reference.

FIRM	ADDRESS	PHONE NUMBER

Assignment Sheet 2

2. Inquire at each of these firms if they employ civil technicians and if they will be hiring in the near future. If a firm is currently not hiring, ask how they go about filling openings (newspaper ads, job placement at your school, employment agency, etc.)

FIRM	OPENINGS	HIRING PROCEDURE

3. Make a list of local, county, and state agencies that hire civil technicians.

AGENCY	ADDRESS

4. Find out what federal agencies in your area hire civil map technicians.

AGENCY	ADDRESS

508

5. Look in the major local paper and clip out any ads for civil technicians. Attach to this assignment sheet.

6. Look in your local phone directory for any private consulting engineers and list below.

   Note: Many consulting firms hire civil technicians on a contract basis.

7. List educational requirements that are prerequisites for working as a civil technician.

Objective 14

Assignment Sheet 3—Access the Internet for Mapping Resources

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Answers are clear and concise	______
• Assignment is neat and legible	______

Basic Skills

Reading Writing Critical Thinking Technology

Note: Complete this assignment after consulting with your instructor.

Directions

Using Student Supplement 4, Internet Addresses for Mapping Resources, select two web sites to access through your Internet provider.

Note: If you do not have access to the Internet through your school or at home, check your local library for on-line access.

The purpose of this assignment is to show how resources for the civil field may be located through the resources found on the Internet.

Step 1 Select an Internet address from Student Supplement 4.

Step 2 Go on-line and locate the address you have selected.

Step 3 Complete the following questions for each web site.

1. List the web site address. ______________________
2. What type of mapping agency is this web site? ______________________
____
3. List other web site addresses found on this web site.
____
____
____
____

4. Are there any resources that can be downloaded to your hard drive?

____

____

____

____

____

5. What new information did you learn about maps from this web site?

____

____

____

____

____

Repeat this exercise with two more web sites listed in Student Supplement 4.

Map Scales and Measurement

Unit Contents

Student Components

Student Page

Objective Sheet 2–3

Information Sheet 2–5

Student Supplements

1—Quadrangle Map Scales, Sizes, and Area 2–13
2—Graphic Scales 2–15

Assignment Sheets

1—Convert a Representative Fraction to a Graphic Scale 2–17
2—Measure With a Civil Engineer's Scale 2–19
3—Measure Distances on a 7.5 Minute Quadrangle 2–21
4—Use a Civil CAD Software Program to Set Project Parameters 2–23

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify standard scale ratios used on topographic quadrangle maps, measure with a civil engineer's scale, and set project parameters. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to map scales and measurement with their definitions.
2. Complete a chart of standard measures and their equivalents.
3. Select true statements concerning accuracy and precision.
4. Complete statements about choosing a map scale.
5. Select true statements concerning characteristics of map scales.
6. List the three ways map scales are expressed.
7. Match the ranges of map scales with the appropriate map scale classifications.
8. List factors affecting the selection of a map scale.
9. Match common types of maps with their corresponding map scales.
10. Define a minute on the globe.
11. Select characteristics of a quadrangle scale.
12. Match quadrangle scales commonly used on USGS topographic maps with their equivalents.
13. Select true statements concerning characteristics of graphic scales.
14. Select true statements concerning published map accuracy standards.
15. Match types of scales used in civil drafting with their descriptions.
16. Select the true statement concerning map scale in CAD.
17. Convert a representative fraction to a graphic scale. (Assignment Sheet 1)
18. Measure with a civil engineer's scale. (Assignment Sheet 2)
19. Measure distances on a 7.5 minute quadrangle. (Assignment Sheet 3)
20. Use a civil CAD software program to set project parameters. (Assignment Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Accuracy**—The degree of conformity of a measured or a calculated value to some recognized standard or specified value

b. **Deviation**—Variation from a specified dimension or design requirement, usually defining upper and lower limits

c. **English system**—A standard of measure used in the United States; the basic unit of measurement is the foot.

d. **Full-divided scale**—A scale with the basic units subdivided throughout the length of the scale

e. **Gons**—A term used interchangeably with grads

f. **Grad**—An angular unit of measurement

g. **Graduations**—The subdivisions in a scale unit, all of which are equal in size or length

h. **Hectare** (HA)—One hectare is equivalent to a square having sides of 100 meters; 1 hectare = 2.471 acres

i. **Meter** (m)—The metric system standard for linear measurement

j. **Metric system**—A decimal system of weights and measures based on the meter and the kilogram

k. **Neutral scale**—A scale expressed as a fraction or a ratio

l. **Nominal**—Describes a value assigned for the purpose of convenient designation; existing in name only

m. **NTS**—Abbreviation meaning "not-to-scale"

n. **Open-divided scale**—A scale with only the end unit subdivided into fractional parts

o. **Precision**—The degree of mutual agreement between individual measurements, namely repeatability and reproducibility

p. **Representative fraction** (RF)—A simple ratio or fraction

Example: 1:24,000 or 1/24,000

q. **Scale**—An instrument used as a standard or reference when drawing an object to a proportional size

r. **Scale ratio**—A relationship between dimensional values used to reduce or enlarge the size of an object so that it can be drawn proportionally

s. **SI**—International system of units (metric system)

t. **Significant digit**—Any numeral that is necessary to define a value or quantity

u. **Tolerance**—The total range of variation permitted for size, position, or other required quantity

v. **U.S. customary units**—Units based upon the yard and the pound commonly used in the United States

Objective 2

Standard measures and equivalents

1 mile = 1750 yards = 5280 feet = 1.6093 Km = 8 furlongs = 80 chains
1 yard = 3 feet = 36 inches = 0.9144 meter
1 foot = 12 inches = 0.3048 meter
1 inch = 2.54 centimeters
1 rod (also called *pole* or *perch*) = 5.5 yards = 16.5 feet = 0.5029 decameter

1 furlong = 10 chains = 220 yards
1 chain = 4 rods = 22 yards = 66 feet = 100 links = 2.0116 decameters
1 link = 7.92 inches
1 square mile = 640 acres = 6400 sq. chains
1 acre = 10 sq. chains = 4840 sq. yards = 43,560 sq. feet
An acre is equal to a square, one side of which is 208.7 feet.

1 millimeter (mm) = 0.0393 inch
10 millimeters (mm) = 1 centimeter (cm) = .3937 inch
10 centimeters = 1 decimeter (dm) = 3.9370 inch
10 decimeters = 1 meter (m) = 39.3707 inches = 3.2808 feet = 1.0936 yards
10 meters = 1 decameter (Dm) = 32.8089 feet
10 decameters = 1 hectometer (Hm) = 19.9278 rods
10 hectometers = 1 kilometer (Km) = 1093.61 yards = 0.6213 miles
10 kilometers = 1 myriameter (Mm) = 6.2138 miles

Objective 3

The difference between accuracy and precision

a. Accuracy refers to correctness.

- An answer is accurate or it is wrong.
- An accurate measurement does not tell you the degree of precision.
- A number can be accurate but not precise.
- Work must always be accurate.

b. Precision is a matter of degree.

- The degree of precision you select should be based on what is dictated by jurisdiction or the client.
- Number 10.01 is precise to within $^1/_{100}$ ft.
- The degree of precision of the answer cannot exceed the degree of precision of the least precise value in the equation.
- The degree of precision depends on the size of the parcel to be measured.

Objective 4

Choosing a map scale

a. The choice of map scale depends on how you intend to use the map.

b. A large scale map shows more detail but less land area.

c. A small scale map shows less detail but a larger land area.

Objective 5

Characteristics of map scales

a. Map scale is the relationship between a distance on a map and the corresponding distance on the ground.

b. Scale is usually expressed as a ratio. A map scale expressed as 1:24,000 means that one unit of measurement on the map represents 24,000 of the same units on the earth's surface. If the unit is an inch, then 1 inch on the map equals 24,000 inches on the ground.

c. The first number (map distance) is always 1. The second number (ground distance) differs for each scale.

d. The **larger** the second number, the **smaller** the scale of the map.

Examples: 1:125,000 map is a smaller scale map than a map with a map scale of 1:100,000.

1:63,360 map is a smaller scale map than a map with a map scale of 1:62,500.

Objective 6

Ways map scales are expressed

a. By ratio or representative fraction

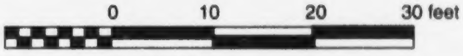
Example: 1:24,000 or $^{1}/_{24,000}$

b. By equivalence

Example: 1 inch = 200 feet

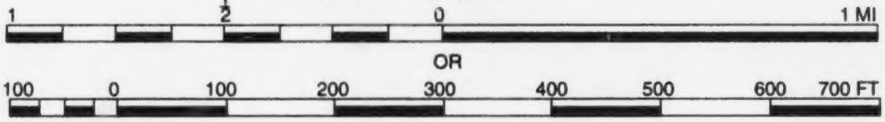
c. Graphically

Examples:



SCALE: 1" = 10 FT

SCALE 1:24,000



Objective 7

Ranges of map scales

a. Large scale maps—1 in = 100 ft (1:1200) or larger

b. Medium scale maps—1 in = 100 to 1000 ft (1:1200 to 1:12,000)

c. Small scale maps—1 in = 1000 ft (1:12,000 or smaller)

Objective 8

Factors affecting the selection of a map scale

a. Size and character of the area to be shown

b. The form that the map is to be presented in

c. Purpose of the map

d. Cost of preparation and length of service (sometimes a consideration)

e. Required precision

Objective 9

Common types of maps and corresponding map scales

a. Geographic maps—Scales vary from a few miles to the inch to several hundred miles to the inch

b. Topographic maps

- Maps drawn at larger scales such as 1:24,000—1:25,000
    - Provide detailed information about the natural and man-made features of an area
    - Are commonly used for highly developed areas in order to show more detail
- Intermediate scale maps 1:50,000—1:100,000

  Example: County map
- Maps drawn at smaller scales such as 1:250,000—1:7,500,000
    - Can only show major features of an area
    - Can be used for more sparsely settled regions because there are not as many details to be shown
    - Allow large areas to be shown on a single map sheet

c. Cadastral maps—Drawn at a scale usually greater than 6 inches to one mile which is necessary to obtain the required accuracy

d. Engineering maps—Scales normally range from 1″ = 20 ft. to 1″ = 400 ft.

Objective 10

Definition of a minute on the globe—A unit of angular measurement equal to one-sixtieth of a degree; the entire globe contains 360 degrees

Objective 11

Characteristics of a quadrangle scale

a. Measures a standard four-sided area (quadrangle)

b. Bounded by lines of longitude and latitude

c. Set by the United States Geologic Survey

d. Most U.S. topographic maps cover 7.5 minutes of latitude and 7.5 minutes of longitude, and are commonly called "7.5 minute quadrangle" maps. These maps are drawn at a 1:24,000 scale. A standard 7.5 minute quadrangle map represents an area approximately 7 miles from east to west and 8 miles north to south.

Objective 12

Quadrangle scales commonly used on USGS topographic maps

Scale	1 inch equals
1:20,000	Approximately 1,667 feet
1:24,000	Exactly 2,000 feet (7.5 min. series)
1:25,000	(7.5 x 15 min. metric series)
1:30,000	Exactly 2,500 feet
1:31,680	Exactly 1/2 mile
1:50,000	(County quadrangle series)
1:62,500	Approximately 1 mile (15 min. series)
1:63,360	Exactly 1 mile (15 min. Alaska series)
1:100,000	(30x60 minute series)
1:125,000	Approximately 2 miles
1:250,000	Approximately 4 miles (1 x 2 degree series)
1:500,000	(State map series)
1:1,000,000	Approximately 16 miles (International Map of the World (IMW) Series)
1:2,000,000	(National atlas sectional map series)
1:2,500,000	(United States)

Metric system

Scale	1 cm represents
1:100,000	1.00 km
1:50,000	0.50 km
1:25,000	0.25 km
1:20,000	0.20 km

Objective 13

Characteristics of graphic scales

a. Are like small rulers that measure distances on a map

Note: A portion of a map can be measured by gauging the distance with dividers, then comparing it to the graphic scale.

b. Consist of a bar drawn at the same scale as the map

c. Begin at zero

- Whole units are subdivided to the right of the zero.
- Smaller subdivisions of a whole unit are to the left of the zero.

d. Are used anytime that a map may become subject to reduction, enlargement, or reproduction for use in reports

e. Are more often used on topographic maps

f. Are usually located in the margins or near the north arrow or legend of the map

Objective 14

Published map accuracy standards

a. Horizontal accuracy

- On maps with scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than $^{1}/_{30}$ inch.
- On maps with scales of 1:20,000 or smaller, the error factor is $^{1}/_{50}$ inch (0.05 centimeters).
- These limits of accuracy apply in all cases to positions of well-defined points that are easily visible or recoverable on the ground such as monuments, intersections of roads, or railroads.

b. Vertical accuracy

- On contour maps (all publication scales), not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval.

  Example: If a map's contour interval is 10 ft, the map will correctly place 90 percent of all points tested within 5 feet (1.5 meters) of actual elevation.

- In checking elevations, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

c. Published maps meeting these accuracy requirements must state in the legend "This map complies with National Map Accuracy Standards."

d. If a map is an enlargement of a published map, this fact should be stated in the legend, such as "This map is an enlargement of a 1:20,000 scale map drawing" or "This map is an enlargement of a 1:24,000 scale published map."

Note: Individual engineering firms will have their standards of accuracy. A civil technician needs to become familiar with these standards.

Objective 15

Scales used in civil drafting

Note: Refer to MAVCC's publication *Basic Drafting*, for an in-depth coverage of the architect's scale, civil engineer's scale, and metric scale. This unit serves to act as a review of these three scales.

a. Architect's scale—Used primarily for drawings of buildings, piping systems, and other large structures which must be drawn to a reduced scale to fit on a standard sheet size. Only occasionally used for civil work. Has one full-size scale and ten reduced-size scales.

b. Civil engineer's scale—Used for civil engineering work. Graduated in units of one inch divided into 10, 20, 30, 40, 50, and 60 parts.

Note: This is the preferred scale for civil work.

c. Metric scale—Used primarily when International System of Units (SI) metric method of measurement is in use. Graduated in millimeters, and uses scale ratios of 1:1, 1:2, 1:5, and 1:25.

Objective 16

Map scale in CAD

a. All data downloaded to the computer is at 1:1.

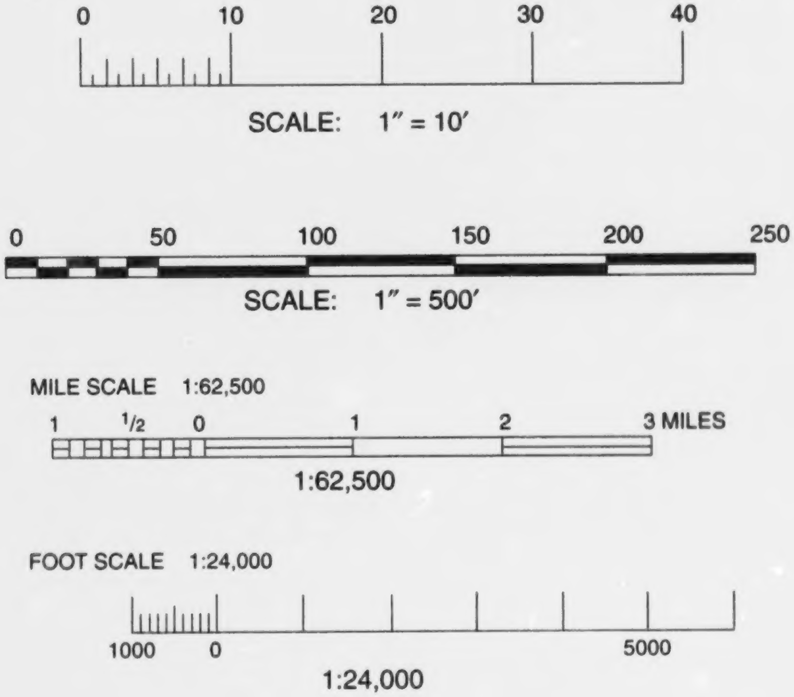
b. All data manipulation in the computer should be done at the 1:1 scale so accuracy and integrity of data remains the same.

c. The scale for final map presentation is determined at the time of plotting. This leaves original data at a 1:1 scale.

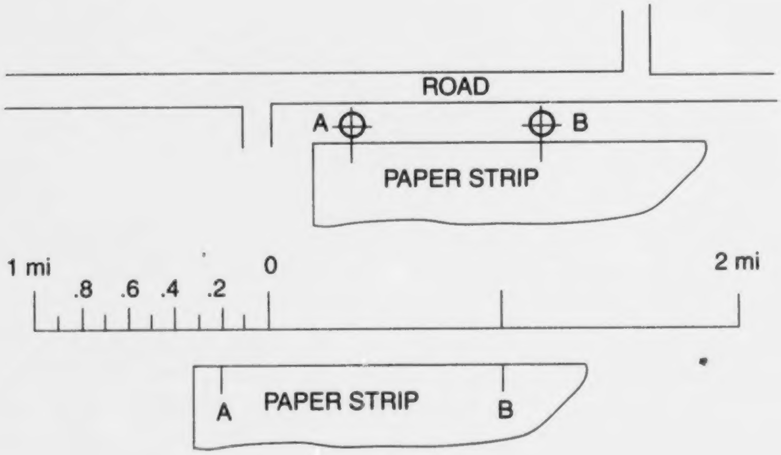
Student Supplement 1—Quadrangle Map Scales, Sizes, and Areas

Series	Scale	1 inch represents approximately	1 centimeter represents	Size (latitude x longitude	Area (square miles)
Puerto Rico 7.5 minute	1:20,000	1,667 feet	200 meters	7.5 x 7.5 min.	71
7.5-minute	1:24,000	2,000 feet (exact)	240 metes	7.5 x 7.5 min.	49 to 70
7.5 x 15-minute	1:25,000	2,083 feet	250 metes	7.5 x 15 min.	98 to 140
USGS/DMA 15-minute	1:50,000	4,166 feet	500 metes	15 x 15 min.	197 to 282
15-minute	1:62,500	1 mile	625 metes	15 x 15 min.	197 to 282
Alaska 1:63,360	1:63,360	1 mile (exact)	633.6 metes	15 x 20 to 36 min.	207 to 281
County 1:50,000	1:50,000	4,166 feet	500 metes	County area	Varies
County 1:100,000	1:100,000	1.6 miles	1 kilometer	County area	Varies
30 x 60-minute	1:100,000	1.6 miles	1 kilometer	30 x 60 min.	1,568 to 2,240
U.S. 1:250,000	1:250,000	4 miles	2.5 kilometers	1° x 2° or 3°	4,580 to 8,669
Antarctica 1:250,000	1:250,000	4 miles	2.5 kilometers	1° x 3° to 15°	4,089 to 8,336
Antarctica 1:500,000	1:500,000	8 miles	5 kilometers	2° x 7.5°	28,174 to 30,462
State maps	1:500,000	8 miles	5 kilometers	State area	Varies
U.s. 1:1,000,000	1:1,000,000	16 miles	10 kilometers	4° x 6°	73,734 to 102,759
U.S. Sectional	1:2,000,000	32 miles	20 kilometers	State groups	Varies

Student Supplement 2—Graphic Scales


0
10
20
30
40
SCALE: 1″ = 10′
0
50
100
150
200
250
SCALE: 1″ = 500′
MILE SCALE 1:62,500
1
1/2
0
1
2
3 MILES
1:62,500
FOOT SCALE 1:24,000
1000
0
5000
1:24,000

Sample Scales


ROAD
A
B
PAPER STRIP
1 mi
.8
.6
.4
.2
0
2 mi
PAPER STRIP
A
B

Measuring with a Graphic Scale

Objective 17

Assignment Sheet 1—Convert a Representative Fraction to a Graphic Scale

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Step I–Math calculation was correct	______
• Step II–Math calculation was correct	______
• Step III–Answer clear and concise	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics

Note: Complete this assignment after consulting with your instructor.

Introduction

Map scales are often given in a ratio such as 1:24,000. In order to show a graphic scale, it is necessary to convert the ratio scale (RF scale) to a graphic scale for display on the map. An example of the conversion process follows.

Note: Student Supplement 1 gives the common maps scales and their equivalents for future reference.

Example: Given: RF scale 1:62,500

Note: Remember 1 equals 1″ on the map and 62,500 equals 62,500″ on the earth's surface.

Step 1

Determine how many miles are represented by 62,500 inches.

(63,360 inches = 1 mile)

Divide 62,500 by 63,360 to determine the miles.

$$\frac{62{,}500}{63{,}360} = .98 \text{ miles}$$

Note: This is not a practical scale to create a graphic scale.

Assignment Sheet 1

Step 2 Determine how many inches are used to show any even numbers other than the .98 miles previously determined. Let's use 2 miles.

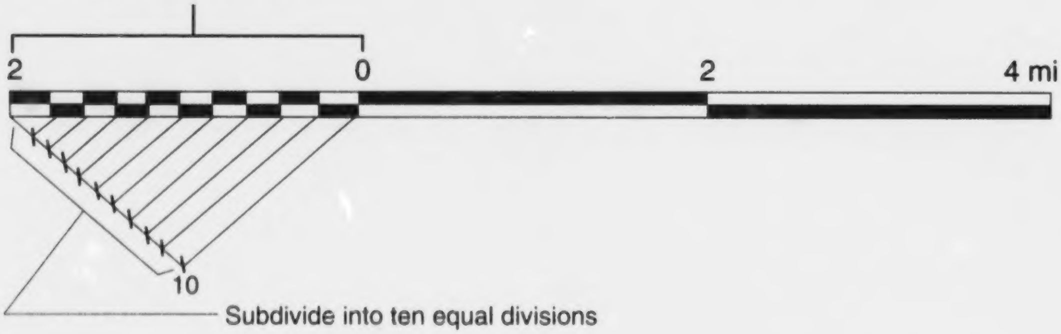
$$\frac{.98}{1 \text{ in.}} = \frac{2 \text{ miles}}{X \text{ (unknown no. of inches)}}$$

Note: Use cross-multiplication to establish this algebraic formula.

$$.98\,X = 2$$
$$X = 2.04''$$

In 2.04 inches we have 2 miles.

Step 3 Lay off a graphic scale using the information on the previous page.



Equals 2.04 inches

Subdivide into ten equal divisions

Problem Given 1:300,000 RF scale

Directions

1. Convert the RF scale into a figure usable for a graphic scale.
2. Draw the graphic scale for this RF scale.

Step 1 = ________________ miles

Step 2 Use 10 miles

$$\frac{\underline{\hspace{3em}}}{1 \text{ in.}} = \frac{10 \text{ miles}}{X}$$

Step 3 Draw the graphic scale here.

Objective 18

Assignment Sheet 2—Measure with a Civil Engineer's Scale

Name ________________________ Overall Rating __________

Date ________________________

Evaluation Criteria	Rating
• Lines are accurately measured	____
• Assignment is neat and legible	____

Basic Skills

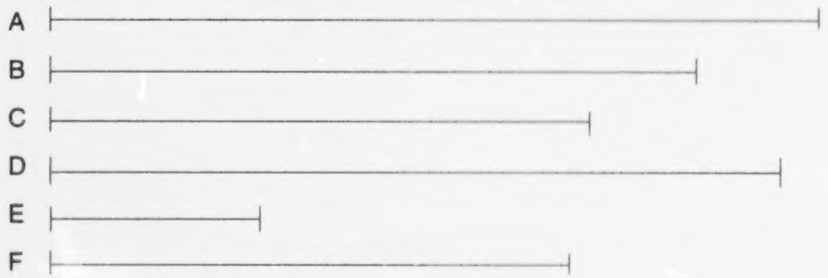
Reading Mathematics

Note: Complete this assignment after consulting with your instructor.

Directions

Use a civil engineer's scale to measure the lines A through F to the scale ratio heading each column in the table. Place the scale readings in the appropriate spaces in the table.

Example: On a 1″ = 10′ scale ratio, line A would be 44′ long; this figure should be lettered under the 1″ = 10′ column opposite letter A.



LINE	1″ = 10′	1″ = 20′	1″ = 300′	1″ = 40′	1″ = 500′	1″ = 60′	1″ = 10 MILES
A	44′						
B							
C							
D							
E							
F							

Objective 19

Assignment Sheet 3—Measure Distances on a 7.5 Minute Quadrangle

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Measurement readings were accurate	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics

Directions

Locate a 7.5 minute USGS quadrangle map, then complete the following:

1. Write in the quadrangle name. ______________________
2. What is the map scale in ratio format? ______________________
3. What is the map scale in graphic format? ______________________
4. Locate 4 sets of features to measure between.

	From	To	Distance
Ex.	Mt. Evans	(Bench Mark) BM 5280′	4,281 Feet
1.			
2.			
3.			
4.			

Objective 20

Assignment Sheet 4—Use a Civil CAD Software Program to Set Project Parameters

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criterion	Rating
• Parameters are set to provided map requirements	______

Basic Skills

Reading Mathematics Technology

Given

A set of map standards for the "MAVCC Topographic Survey Map."

Units: Meter—3 places
Feet—2 places

Precision: Angle—4
Horizontal—2
Vertical—2
Coordinates—4

Scale: 50

Text size: L80

Node size: 3

Directions

Log on to your computer and go into your civil CAD software program. Locate the Parameter Dialog Box. Insert the parameter standards given above.

Have your instructor check the accuracy of your work.

Unit 3

Computer Applications in the Civil Engineering Field

Unit Contents

Student Components

Student Page

Objective Sheet 3–3

Information Sheet 3–5

Assignment Sheets

1—Research Available CAM Software and the Hardware Requirements 3–23
2—Research Computer Applications in the Civil Engineering Field 3–25
3—Import and Print Out an ASCI Point File Using a Civil CAD Software Program 3–29

Objective Sheet

Unit Objective

After completing this unit, the student should be able to select computer mapping applications common to civil software (CAM) and import and print out an ASCI point file using a civil software program. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to civil mapping computer software with their definitions.
2. List basic CADD operations performed by a civil technician.
3. Select from a list the advantages of computer applications in mapping.
4. Define digital cartography.
5. List types of geographic or land systems that utilize digital data information.
6. List types of digital cartographic and geographic data.
7. Select true statements concerning characteristics of digital cartographic and geographic data.
8. List types of computer aided map (CAM) software.
9. Select true statements about features of each of the main civil software modules.
10. List parameters required to be set for a computer mapping project.
11. List other types of digital or computer enhanced mapping tools.
12. Research available CAM software and the hardware requirements. (Assignment Sheet 1)
13. Research computer applications in the civil engineering field. (Assignment Sheet 2)
14. Import and print out an ASCI point file using a civil CAD software program. (Assignment Sheet 3)

Information Sheet

Objective 1

Terms and definitions

a. **Attribute**—Descriptive characteristic of a feature

Note: An attribute value is a measurement assigned to an attribute for a feature instance.

b. **Automatic snapping**—System capability for completing a line segment whose end falls within a predefined proximity to an intersection or node, without operator intervention

c. **CAD**—Computer-aided design

d. **CADD**—Computer-aided design and drafting

e. **CAM**—Computer-aided software that assists the operator in standard mapping operations

f. **CPU**—Central processing unit; part of the computer that performs the calculations and logic

g. **CPU time**—Actual computational time necessary to process a set of instructions in the arithmetic and logic units of the computer

h. **Database**—A collection of information related by a common fact or purpose

i. **Database creation**—Process of bringing data into the electronic environment of a database for later use

j. **Database development**—Process of determining what elements will be included in a database and their internal relationships

k. **Data capture**—Series of operations required to encode data in a computer-readable digital form (digitizing)

l. **Database management system (DBMS)**—Software designed to access and structure a database

m. **Digital data**—Of, or relating to data in the form of digits; data displayed, recorded, or stored in binary notation

n. **Digital elevation model (DEM)**—A file with terrain elevations recorded at the intersections of a fine grid and organized by quadrangle to be the digital equivalent of the elevation data on a topographic base map

o. **Digital terrain model (DTM)**—A land surface represented in digital form by an elevation grid or lists of three-dimensional coordinates

p. **Digitize**—To translate two-dimensional information into an electronic format for use in a computer

q. **Digitizing**—Process of converting an analog image or map into a digital format usable by a computer

r. **DTM**—Digital terrain modeling; a technique for translating three-dimensional topographic information onto a two-dimensional surface

s. **GIS**—Geographic information system; a map including a wide variety of information about a particular geographic area; usually on electronic medium

t. **Graphic entities**—Entities which are graphically portrayed as geometric shapes or symbols on the source document

u. **Grid**—A network of uniformly spaced horizontal and vertical lines that enclose an area (a cell) with an associated value assigned

v. **Hard copy**—Printed paper or film copy of machine output in a visually readable form such as printed reports, listings, graphs, drawings, maps, or summaries

w. **Hard disk**—Permanent magnetic disk within a computer that holds the permanent information stored

x. **Hardware**—The computer itself and its peripherals

y. **Import**—Process of bringing data or software from another system into a system

z. **Interactive**—A system allowing two-way electronic communication between the user and the computer

aa. **Layers**—The various "overlays" of data, each of which normally deals with one thematic topic

Note: These overlays are registered to each other by the common coordinate system of the database.

bb. **Merge**—To take two or more maps or data sets and combine them into a single, coherent map or database without redundant information

cc. **Modem**—A device which interprets computers' electronic impulses into frequencies within the audio range, and vice versa, for the use of telephone lines to communicate computer information

dd. **Node**—Represents the intersection points and the endpoints of lines. Each node is uniquely numbered and is located by a pair of X, Y geographic coordinate values

ee. **Off-line**—Transmission of information between a computer and a peripheral unit before or after, but not during, processing, in contrast to on-line processing ff. **On-line**—Transmission of information between a computer and a terminal or display device while processing is occurring, in contrast to off-line processing

gg. **Overlay**—Data layer usually dealing with only one aspect of related information which is used to supplement the database. Overlays are registered to the base data by a common coordinate system

hh. **Photogrammetrically digitized**—Digitized from aerial photographs and geodetic control data by means of photogrammetric instruments, providing three-dimensional coordinates

ii. **Pixel**—Short for "picture element"; the smallest discrete element which makes up an image

jj. **Raster**—Pattern of horizontal, parallel scan lines comprising the image on a cathode ray tube screen, on which each scan line consists of segments varying in intensity

kk. **Resolution**—Measure of the ability of a display system to distinguish detail under certain specific conditions. The measure of this ability is normally expressed in lines per millimeter, meters per pixel, dots per inch, etc.

ll. **Scanning**—Process of using an electronic input device to convert analog information such as maps, photographs, or overlays, into a digital format usable by a computer

mm. **Software**—Instruction information for the computer. There are two types: (1) system software, made up of operating systems, communications software, and database managers; and (2) applications software, the specific programs the user chooses to accomplish particular tasks

nn. **Spatial analysis**—Analytical techniques associated with the study of the location of geographical entities together with their spatial dimensions; also referred to as quantitative analysis

oo. **Spatial data**—Data pertaining to the location of geographical entities together with their spatial dimensions. Spatial data are classified as point, line, area, or surface

pp. **Spreadsheet**—A matrix of rows and columns used for a wide variety of calculations and comparisons of information

qq. **TIN**—Triangulated irregular network; a data structure which describes a three-dimensional surface as a series of irregularly shaped triangles; usually used in connection with terrain modeling

rr. **Topological**—Refers to such properties of geometric figures as adjacency that are not altered by distortion as long as the surface is not torn ss. **Topologic error checking**—Process of ensuring that the logical consistency of the data is intact, that is, all polygons are closed, all arcs are connected to nodes, etc.

tt. **Topological relationships**—Refers to how data elements relate to each other within the database. In particular, how a change to one element affects other elements

uu. **Topology**—A branch of geometrical mathematics which is concerned with order, contiguity, and relative position, rather than actual linear dimensions

vv. **Two-dimensional (2D) data**—Aerial data in two dimensions, such as northing-easting or latitude-longitude

ww. **User interface**—Method by which the human operator communicates with the various database and applications modules

xx. **Window**—Rectangular frame with a specified size and location on the screen of an interactive graphics system, and within which a rectangular portion, or window, of the map is displayed

Objective 2

Basic CADD operations performed by a civil technician

a. Create geometric shapes with or without specifying size

b. Create lines from the exact endpoints of other lines

c. Create lines perpendicular or parallel to other lines

d. Change the scale of all or a selected portion of a drawing

e. Rotate all or a portion of a drawing by a specific or unspecified amount

f. Create a parallel line at a specified offset distance

g. Create a mirror image of all or a portion of a drawing

h. Copy an area or one element of a drawing to another location or to multiple locations

i. Extend a line to some specified location

j. Trim a line

k. Create a line of specified bearing and distance

l. Create tangents to circular curves from specified points

m. Create a circular curve by specifying two elements of the curve data

n. Create a circular curve tangent to one or two lines by specifying two elements of the curve data

o. Label lines and curves with bearing and distances or curve data

p. Label coordinates

q. Trace information into the computer

Objective 3

Advantages of computer applications in mapping

a. Information is gathered, files built, and map data managed more efficiently

b. Data is more precise

c. CAD reduces cost of map production

- Speeds up map creation
- Ensures data integrity

d. Standardization of layouts

- Title blocks
- Legends
- North arrows
- Scale bars
- Insets

e. Maps can be shared without compromising data

f. Map data integrity can be protected through multiple levels of security

g. Can convert a data file into a thematic map

h. Data can be separated into layers

i. Quick map editing

j. Can access and query multiple map database and improve map production

k. Maps can be plotted or printed in color

l. Databases can be customized based on different needs and criteria

Objective 4

Digital cartography—The collection, storage, processing, analysis and display of map data with the aid of computers

Objective 5

Types of geographic or land systems that utilize digital data information

a. Transportation planning

b. Town and urban planning

c. Environmental impact studies

d. Land use planning

e. Mineral resource assessment

f. Wildlife habitat assessment

g. Resource management
h. Hydrologic modeling
i. Rangeland inventories
j. Irrigation potential determinations
k. Geologic assessments
l. Visual interpretations
m. Land cover diversity estimates
n. Vegetation inventories
o. Soil surveys
p. Forest fire behavior predictions
q. Earthquake hazards mapping
r. Coastal zone management
s. Environmental assessment
t. Geographic names analysis

Objective 6 **Types of digital cartographic and geographic data**

Note: The increasing use of computers for storing and analyzing earth science information has increased the demand for digital cartographic and geographic data.

a. Elevation data
b. Planimetric data
c. Geographic names information
d. Land use and land cover data
e. Software
f. Hydrography data
g. Transportation data

Note: All digital data is available through USGS (US Geo Data) 1-800-USA-MAPS.

Objective 7

Characteristics of digital cartographic and geographic data

a. Elevation data

Figure 1

U.S. Geological Survey

- Digital elevation models (DEM) are records of terrain elevations at regularly spaced horizontal intervals.
- Elevation data are available in 7.5 minute, 15 minute, 30 minute, and 1-degree units.

  Note: 7.5 minute DEM generally corresponds to the USGS 7.5 minute topographic quadrangle maps.
- Data consists of a regular array of elevations referenced horizontally to the Universal Transverse Mercator (UTM) coordinate system.
- Data is stored as profiles.
- With appropriate software, DEM data may be used to generate graphics displaying slope, direction of slope (aspect) and terrain profiles between selected points, determining volume and calculating amounts of material.

b. Planimetric data

- Commonly known as digital line graphs (DLG); are the digital representation of the cartographic line information on a map
- DLG are available for scale maps:

— 1:20,000	— 1:62,500
— 1:24,000	— 1:63,360
— 1:25,000	— 1:100,000
— 1:48,000	— 1:2,000,000

- DLG have five major data categories:
  - Public Land Survey System—Township, range and section
  - Boundaries—State, county, city, civil divisions and state and federally administered lands
  - Transportation—Roads, trails, railroads, pipelines, transmission lines
  - Hydrography—Streams and water bodies
  - Hyposgraphy—Contours
  - Other data categories—Cultural features, vegetative surface cover, nonvegetative features, and survey control and markers
- DLG's are topologically structured; this means that spatial relationships inherent in the map have been preserved
- DLG's are in two formats:
  - Standard—Are encoded using an internal file coordinate system (Cartesian) based on a one-thousandths of a map inch
  - Optional—Are expressed in metric units of the Universal Transverse Mercator (UTM) coordinate system
- The graphics applications format may be used to plot maps that show only selected combinations of categories (i.e. national forest lands and railroads) or can be used to calculate distances between locations (i.e. determine the length of a shoreline)

c. Geographic Names Information System (GNIS)

- GNIS consists of three separate databases:
  - National Geographic Names Database
  - USGS Topographic Map Names Database
  - Reference Database

- National Geographic Names Database contains data files of over 2 million places and feature names in the USA.
- USGS Topographic Map Names Database is the official inventory of all topographic maps planned or published by the USGS.
- Reference database catalogs every type of feature. Sixty-three broad categories of feature types have been defined (i.e. rivers, creeks, brooks, branches, runs are categorized as stream)

d. Land Use and Land Cover and associated digital data (LULC)

- LULC digital data are derived from thematic overlays registered to USGS 1 by 2 degrees 1:250,000 scale base maps and a limited number of USGS 30 by 60 minute 1:100,000 scale base maps.
- LULC provide information on:
  - Urban or built-up land
  - Agricultural land
  - Range land
  - Forest land
  - Water
  - Wetlands
  - Perennial snow or ice
- LULC maps display information in five data categories.
  - Political units
  - Hydrologic units
  - Census county subdivisions
  - Federal land ownership
  - State land ownership
- LULC digital data are stored in the UTM coordinate system. This data may be transformed to other map projections and converted to geographic coordinates.

e. Software

- The National Mapping Program of the USGS has developed software to aid in data applications that may require geometric manipulation in surveying, geodesy, remote sensing and photogrammetry.
- Software is available for:
  - Coordinate conversion
  - Aerotriangulation
  - Instrument calibration
  - DEM resampling
  - DLG plotting

Objective 8

Types of computer aided map (CAM) software available

a. Site planning
b. Landscape design
c. Irrigation design
d. Construction details
e. Project manager
f. Virtual simulator
g. Surface modeling (DTM)
h. Site analysis
i. Survey adjustment
j. Coordinate geometry (COGO)
k. Road calculations
l. Drafting
m. Structural
n. Data collection
o. Data transfer
p. Profiles
q. Earthworks
r. Design
s. Hydrology tools
t. Imaging and scanning software
u. GIS—Graphic Information Systems

Note: This computer application will be covered in further depth in Unit 8—Municipal Mapping, Plats and Subdivisions.

540

Objective 9

Features of main civil software modules

Note: There are different commercial civil CAD packages available today. These modules seem to be common to most of them.

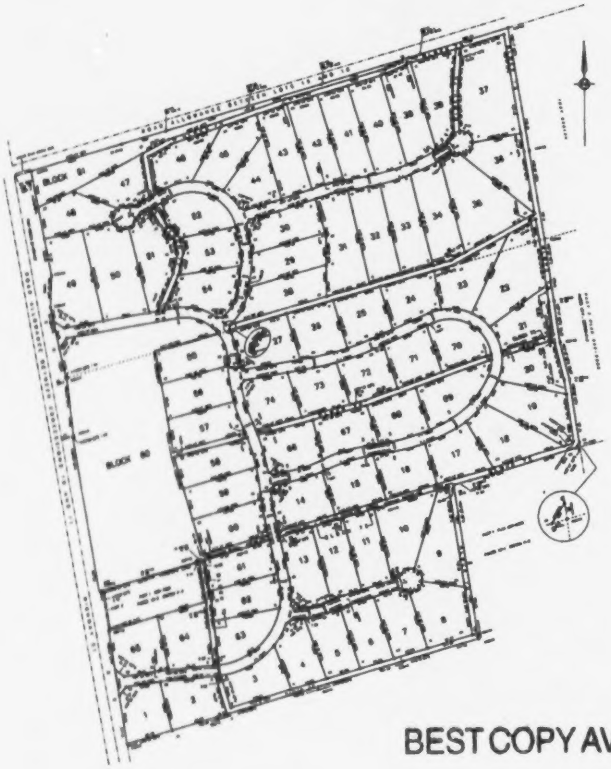
a. Data collection files

- The data collection module is the most important link between data taken in the field and the resulting map created in the office.
- Data files contain terrain data features:
  - — Center line of roads
  - — Edge of road
  - — Ridge lines
  - — Flow lines
  - — Power lines
  - — Trees
  - — Fire hydrants, etc.

Note: Topography (ground shots) are in a separate file.

b. Coordinate Geometry (COGO)—For civil engineering and surveying

Figure 2

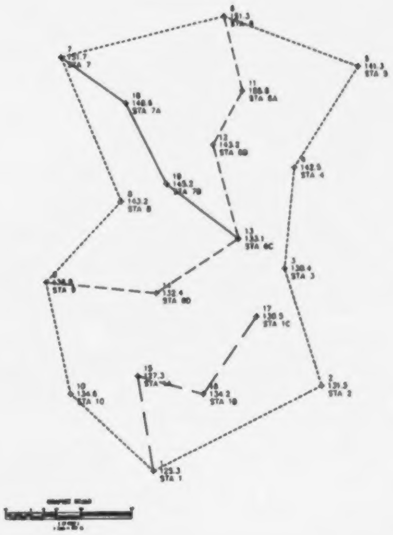


BEST COPY AVAILABLE

- Allows the operator to set and work with points that are stored in a project database
- Is often the base module for other civil software applications
- Has import and export point capabilities
- Is used to check the traverse and define the boundary line of the site
- Provides tools for:
  - — Drawing lines
  - — Drawing arcs
  - — Special line types
  - — Label metes and bounds
- Supports both metric and imperial units
- Provides for point editing and point record locking

c. Survey

Figure 3



- Uses mathematical routines to balance and adjust all points relative to a survey traverse
- Automatically includes detailed reports before and after adjustments with an unlimited number of site points
- Perform least square adjustments and state plane coordinate transformation

- Provides sun and star shot calculations
- Traverse and side shot entry through spreadsheet input
- Data collection downloads from standard data collectors and batch mode input

d. Site design

- A tool to do roadway design, lot design, drain and sewer system development, parking layout, roadway offsets and intersections
- Can produce cross sections to an alignment
- A tool for lot sizing, listing and labeling

e. Earthworks

- Enables site designers to develop and analyze proposed sites with tools for the grading layout of building pads, parking areas, ponds, calculating cut and fill volumes
- Can set points graphically at a slope or at a grade
- Can sketch user defined layers and intervals and convert to polylines

f. Digital Terrain Modeling (DTM)

- A tool to do site analysis through terrain modeling programs
- Creates a surface model and defines surface fault lines
- Editing capabilities
- Generates contours from surface based on user-defined contour increments and layering
- Generates multiple surface cross sections

g. Road calculations

- A tool to design highways and roadways
- Software that can generate alignments, cross sections plan and profile of roadways
- Plots and calculates horizontal and vertical curves
- Calculates earth volumes and pavement volumes

Objective 10

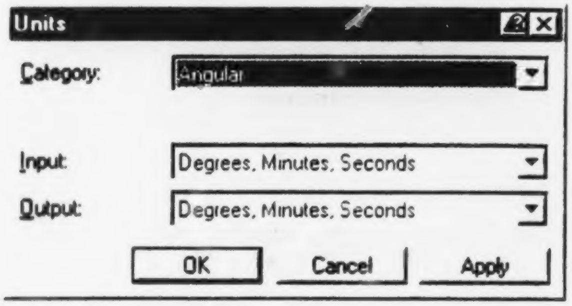
Setting parameters for a computer mapping project

Note: Parameters for a computer mapping project must be set before proceeding with the development of a map.

a. Set units

- Linear units: feet, meters
- Angular units: degrees, minutes, seconds, grads, mils
- Area units: square feet, acres, square meters, hectares
- Degree of curvature: arc, chord

Figure 4



Category: Angular

Input: Degrees, Minutes, Seconds

Output: Degrees, Minutes, Seconds

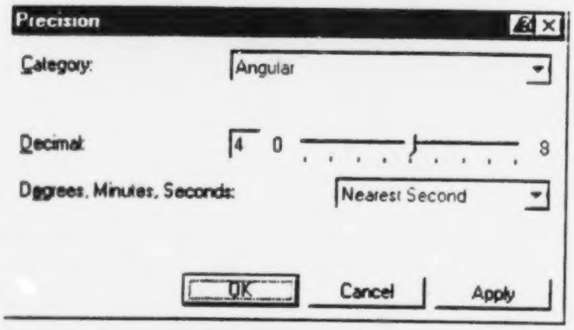
Courtesy of Eagle Point Software

Sample Units Dialog Box

b. Set precision.

- Linear precision: distances, elevations, stations
- Angular precision: nearest second
- Coordinate precision: north, east
- Area precision: square feet, acres

Figure 5



Category: Angular

Decimal: 4

Degrees, Minutes, Seconds: Nearest Second

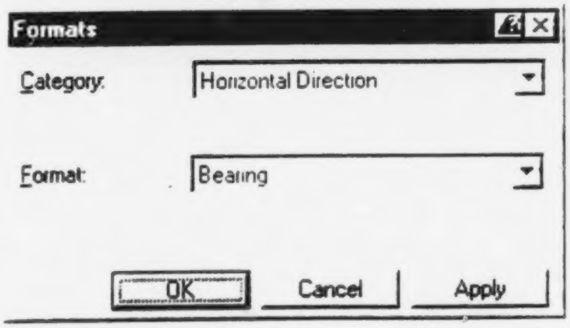
Courtesy of Eagle Point Software

Sample Precision Setup Dialog Box

c. Pick formats.

- Horizontal directions
  - Geometric
  - Bearing
  - North azimuth
  - South azimuth
- Vertical directions
  - Horizontal angle
  - Zenith angle
  - Nadir angle
  - Percent of slope
  - Ratio of slope
- Set station format.
  - 1 + 00
  - 0 + 100

Figure 6



Category: Horizontal Direction

Format: Bearing

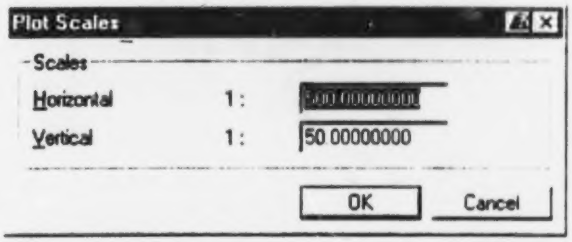
Courtesy of Eagle Point Software

Sample Formats Dialog Box

d. Set drawing scales.

- Horizontal scale (horizontal scale affects plan views, text, annotation, and symbols)
- Vertical scale (vertical scale affects profiles, cross sections, pipes, etc.)

Figure 7



Horizontal 1 : 500.00000000

Vertical 1 : 50.00000000

Courtesy of Eagle Point Software

Sample Scales Dialog Box

e. Set text size and style.

- Leroy/MLeroy
- Inches

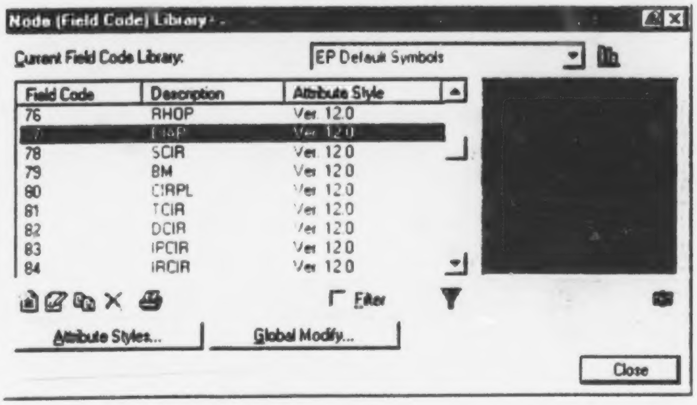
f. Set sheet size.

- 8 1/2 x 11
- 11 x 17
- 18 x 24
- 22 x 34
- 24 x 36
- 28 x 40
- 30 x 42
- 36 x 42
- 36 x 48

g. Set a drawing border.

h. Set node attribute style.

Figure 8



Node (Field Code) Library

Current Field Code Library: EP Default Symbols

Field Code	Description	Attribute Style
76	RHOP	Ver. 12.0
[illegible]	[illegible]	Ver. 12.0
78	SCIR	Ver. 12.0
79	BM	Ver. 12.0
80	CIRPL	Ver. 12.0
81	TCIR	Ver. 12.0
82	DCIR	Ver. 12.0
83	IPCIR	Ver. 12.0
84	IRCIR	Ver. 12.0

[illegible] Eagle Point Software

Sample Nodes (Symbols) Dialog Box

Objective 11

Other types of digital or computer enhanced mapping tools

a. Unprocessed satellite imagery

- Major satellite systems:
  - RADARSAT
  - LANDSAT TM
  - SPOT
  - IRS-IC
  - ERS1
  - JERS 1
  - RESOURS
  - SPIN-2
- Satellite image processing converts raw image data with useful information. Processing options include:
  - Image rectification—Picking points on an image in an x (longitude) and y (latitude) position that directly tie to an x, y location on the earth
  - Ortho rectification—This is commonly used for aerial photos. This rectification adds the Z value (elevation). Geometry is viewed at the sensor (Example: At the camera in aerial photography) to account for the relief distortion caused by topo relief.
  - Image enhancement—Manipulating the digital number value (DN values) to alter the appearance of the image; the most common is the linear stretch. This is used to highlight special features.

  - Image classification—The creation of a thematic map from the digital imagery; the grouping of similar pixel spectral characteristics into a class

  - Image mosaicing—Patching together adjacent images (scenes, photos) that overlap to join each other. Each photo needs to be rectified and tied to real world coordinates.

b. Digital orthophotography—Traditional aerial photography can be scanned into a digital format through high-resolution scanning (up to 3000 dpi). Through this process the photos are orthorectificated, which removes the distortions caused by the camera, the airplane and topography resulting in a planimetric product on which you can accurately measure.

c. Instant imagery in CD-ROM—Printed maps now can be scanned and enhanced and placed on CD-ROM in a ready to use format compatible with CAD, GIS or other analysis programs.

d. Spreadsheet—A matrix of columns and rows. A very flexible software tool for the civil technician to show cost estimates, survey data or other data that needs to be compared

Objective 12

Assignment Sheet 1—Research Available CAM Software and the Hardware Requirements

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Answers are clear and concise	______
• Assignment is neat and legible	______

Basic Skills

Reading Writing Critical Thinking Technology

Note: Complete this assignment after consulting with your instructor.

Directions

Select one of the CAM providers of civil software listed below. (You may choose one not listed here.) Contact them through Internet access or written inquiry. Based on the information located, complete the following sets of questions.

- Autodesk, Inc. (LLD–Softdesk)
  111 McInnis Parkway
  San Rafael, CA 94903 USA
  http://www.autodesk.com

- Eagle Point
  4131 Westmark Drive
  Dubuque, IA 52002
  http://www.netins.net/showcase/eaglewww

1. State which company you are contacting. ______________________

2. List the civil software modules that are available through this company.

____

____

____

____

____

____

Assignment Sheet 1

3. What are the system requirements for running this software?

4. What is the operating system required for these modules?

5. What is the cost of this software?

6. List other information that was provided to you about other software, upcoming products, or a technical tip you learned from this inquiry.

7. Would you purchase this software? ______________

   Why or why not? ______________

8. List the address of a local representative that distributes this software.

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Objective 13

Assignment Sheet 2—Research Computer Applications in the Civil Engineering Field

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Answers are clear and concise	______
• Answers are neat and legible	______

Basic Skills

Reading Writing Oral Communication Critical Thinking Technology

Directions

Note: Complete this assignment after consulting with your instructor.

Choose three different places in your area that may use computer applications.

- Municipal agency
- Private civil engineering firm
- Governmental mapping agency

Visit or write each place and ask the following questions:

Note: Your instructor may wish for you to accomplish this assignment as a group to lessen the inconvenience to businesses.

1. What type of computer graphics systems are they using?

____

____

2. How many work stations do they have? How many remote work stations?

____

____

3. What method are they using for data storage?

____

____

4. What mapping applications are they using? ____________________

____

____

____

____

5. What kind of equipment are they using for data output? ____________

____

6. Who uses the computer graphics system?

______________ Management

______________ Engineers

______________ Drafters

______________ Civil technicians

______________ Secretarial/support staff

7. What method do they use for data input? ____________________

____

8. Do they use the layering capabilities? ____________________

9. Describe how: ______________________________________

____

____

____

10. Write a brief description of how they have their data base set up.

____

____

____

____

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____

11. Give an overall impression of the organization structure for the CAD application. ____________________

12. Do they hire entry level civil technicians with CAD training? ________

Objective 14

Assignment Sheet 3—Import and Print Out an ASCI Point File Using a Civil CAD Software Program

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• ASCI point file is imported correctly	______
• ASCI points print out matches MAVCC's point statistic printout (T.S. 3)	______

Basic Skills

Reading

Critical Thinking

Technology

Note: This assignment may only be done using a civil CAD software program.

Given: User defined ASCI point file for a land parcel on a CD-ROM. This ASCI point file has point data that you will use to build a map of the "MAVCC Topographic Survey."

File Parameter: This ASCI point file is set up with comma delimiters (as opposed to spaces). The data is set up with the following spaces:

6 spaces for point numbers
6 spaces for northings
6 spaces for eastings
6 spaces for elevations
15 spaces for description

Points Northings Eastings Elevations Description
6, 6.6, 6.6, 6.6, 15

This file address is: d:\points.asc

Note: Depending on your computer system your CD-ROM drive may be located on a drive other than the d drive.

Assignment Sheet 3

Directions

Step I: Log on to your civil CAD program. Check that the parameters are set correctly. (See Assignment 4, Unit 2—Map Scales and Measurements.)

Step II: Create a layer and name it.

Step III: Import the ASCI points file.

Note: This file must be imported as a point file not a text file.

Refer to your civil CAD software program for the correct procedure to follow to import your ASCI points file.

Once your ASCI points file is imported, you are ready to begin to build your map of the "MAVCC Topo Survey." Wait for further instruction. Upon completion of subsequent chapters of this book, each component of this map will be completed by you.

Step IV: Print out the ASCI point file:

1. Go into your operating system.

   IF—DOS—Type in: Edit $_{v}$ Points.ASC

   IF—Windows—Go to Dos prompt, put in Edit $_{v}$ Points.ASC

2. You can print from here—Command: Alt File Print⌝

   Check your printout against the MAVCC point statistics printout provided by your instructor.

Example

This procedure is based on the civil CAD program, "SOFTDESK."

Import the ASCI point file: d:\points.asc

1. Layer make points ____________________

   Name

   Layer points. TOPO

2. Import points: You are asked which format you want to use. A screen will pop up. Select commas as the delimiter, etc. (See file parameter for this assignment.) You also select PNEZD (points, northings, eastings, elevation, description).

3. Next you will see a dialog box to locate which file is needed. Here you type in the file address. (d:\points.asc)

4. Then you are asked if you want to append or override this file. You want to append this file.

5. Next you are asked if you want to add a number. You put in yes then add "0".

6. Import the points.

   Note: If you can't see the points on the screen after you have imported them, zoom extents.

Unit 4

Standard Symbols and Abbreviations

Unit Contents

Student Components

Student Page

Objective Sheet 4–3

Information Sheet 4–5

Student Supplement

1—Abbreviations of Commonly Used Words in Civil Drafting 4–27

Assignment Sheets

1—Set Up a Map Legend 4–33

2—Locate and Identify Symbols and Features on a USGS Map 4–35

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Standard Symbols and Abbreviations

Objective Sheet

Unit Objective

After completing this unit, the student should be able to set up a map legend and locate and identify symbols and features on a USGS map. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to standard symbols and abbreviations with their correct definitions.
2. List types of symbols commonly used in civil drafting.
3. Write the abbreviations for words used on public land surveys.
4. Write the abbreviations for words used on construction surveys.
5. Write the abbreviations for words used on property surveys.
6. Match symbols commonly used in surveying with their meanings.
7. Select true statements concerning factors that determine when an abbreviation should be used.
8. State two purposes of symbols on maps.
9. Identify USGS topographic map symbols.
10. Identify other conventional topographic symbols.
11. Identify boundary, fence, and track fixture symbols.
12. Match civil symbols with their meanings.
13. Identify utility and service symbols.
14. Match hydrographic and navigation symbols with their meanings.
15. Match geological structure symbols with their meanings.
16. Complete a chart of oil and gas symbols and their meanings.
17. Draw examples of north arrow symbols.
18. Select true statements concerning general rules for drawing map symbols.
19. List methods used in drawing symbols.

Objective Sheet

20. Match color codes with their corresponding map symbols.

21. Identify common material symbols used in structural and architectural drawings.

22. Complete a chart of standard symbols for pipe fittings.

23. Set up a map legend. (Assignment Sheet 1)

24. Locate and identify symbols and features on a USGS map. (Assignment Sheet 2)

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Information Sheet

Objective 1

Terms and definitions

a. **Boundary**—A line of demarcation between adjoining parcels of land

b. **Cultural features**—Man-made features such as railroads, bridges, roads, and public utilities

c. **Geological**—The structure and composition of the earth's crust

d. **Hydrographic features**—Features along the shore and the submerged parts of bodies of water

e. **Legend**—A description, explanation, table of symbols, and other information which is printed on a map or chart for better understanding and interpretation

Note: The legend includes only those symbols that need an explanation. If a symbol is labeled on the map, it does not need to be included in the legend.

f. **Map scale**—The relationship existing between a distance on a map and the corresponding distance on the earth

g. **Natural land features**—Features on a map such as lakes, streams, terrain, and vegetation

h. **Navigation**—Method of charting waters which affords a channel for useful commerce or travel

i. **Planimetry**—Showing the details of a map in plan view (generally culture and water features)

j. **Symbol**—A diagram, design, letter, or abbreviation which by convention or reference to a legend is understood to represent a specific characteristic or object

Objective 2

Types of symbols commonly used in civil drafting

a. Map symbols

b. Drawing symbols (ANSI standards for types of lines)

c. Labels in the form of abbreviations

d. Pipe symbols

e. Weldment symbols (types of welds)

f. Utility symbols

g. Material symbols

h. Oil and gas symbols

i. GIS symbols

Note: Most symbols today are available in a symbols library in the applicable CAD software. Each is stored as a separate drawing and can be imported into the map or plan drawing as needed.

Objective 3

Abbreviations used on public land surveys

Abbreviation	Word
ac	acres
AMC	auxiliary meander corner
bdy., bdys.	boundary, boundaries
BT	bearing tree
CC	closing corner
ch, chs	chain, chains
cor., cors.	corner, corners
corr.	correction
decl.	declination
dist.	distance
frac.	fractional (sec., etc)
Gr.	Greenwich
G.M.	guide meridian
lk, lks	link, links
meas.	measurement
mer.	meridian
mkd.	marked
Mi. Cor.	mile corner
MC	meander corner
M.S.	mineral survey
pt.	point
Prin. Mer.	principal meridian (P.M.)
R, Rs	range, ranges
R 1 W	range 1 west
SC	standard corner
Sec., Secs.	section, sections
SMC	special meander corner
Stan. Par.	standard parallel (S.P.)
T, Tp, Tps	township, townships
T 2 N	township 2 north
U.S.L.M.	U.S. location monument
U.S.M.M.	U.S. mineral monument
WC	witness corner

Objective 4

Abbreviations used on construction surveys

Abbreviation	Word
b.b.	batterboards
B.L.	building line
C.B.	catch basin
C.G.	center line of grade
℄	center line
const.	construction
C	cut
esmt.	easement
F	fill
F.G.	finish grade, Fin. Gr.
F.H.	fire hydrant
F_L	fence line
F.L.	flow line (invert)
F.S.	finished surface
G.C.	grade change
G.P.	grade point
G.R.	grade rod (s.s. notes)
L	left (x-sect. notes)
M.H.	manhole
P_L	property line
P.P.	power pole
pvmt.	pavement
R	right (x-sect. notes)
R/W	right-of-way
S.D.	storm drain
S.G.	subgrade
S.L.	spring line
spec.	specifications
Sq.	square
s.s.	slope stake, side slope
Std.	standard
Str. Gr.	straight grade
X-sect.	cross-section

Objective 5

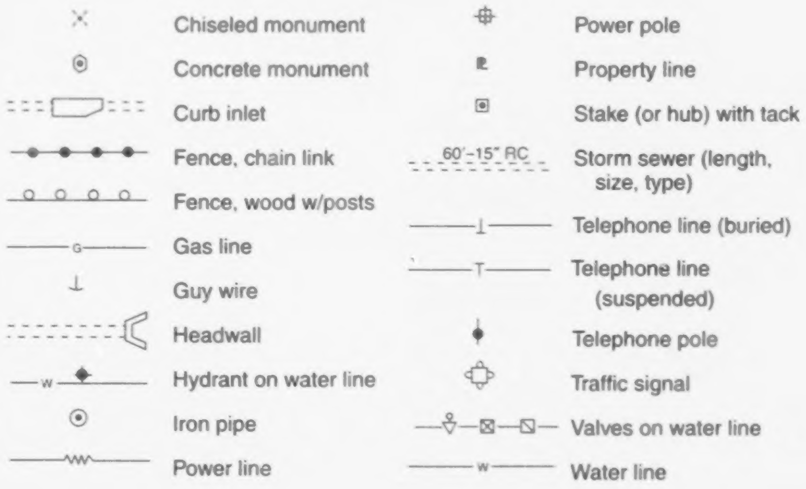
Abbreviations used on property surveys

Abbreviation	Word
A	area
C.F.	curb face
ch "X"	chiseled X cross
C.I.	cast iron
diam.	diameter
Dr.	drive
ER	end of return
Ex.	existing
H & T	hub and tack
H.C.	house connection sewer
I.B.	iron bolt (bar)

I.P.	iron pipe; iron pin
L & T	lead and tack
max.	maximum
min.	minimum
M.H.W.	mean high water
M.L.L.W.	mean low low water
M.L.W.	mean low water
Mon.	monument
No.	number
P	pipe; pin
Rec.	record
St.	street
Std. Surv. Mon.	standard survey monument
Std. Trav. Mon.	standard traverse monument
2″ X 2″	two- X two-inch stake
X	cross cut in stone
yd.	yard

Objective 6

Symbols commonly used in surveying


Chiseled monument
Concrete monument
Curb inlet
Fence, chain link
Fence, wood w/posts
G
Gas line
Guy wire
Headwall
W
Hydrant on water line
Iron pipe
Power line
Power pole
Property line
Stake (or hub) with tack
60′–15″ RC
Storm sewer (length, size, type)
Telephone line (buried)
T
Telephone line (suspended)
Telephone pole
Traffic signal
Valves on water line
W
Water line

Objective 7

Factors that determine when an abbreviation should be used

a. Use an abbreviation when necessary to save time and space.

b. Use an abbreviation only when the meaning is unquestionably clear to the intended reader.

c. Be sure to use a standard abbreviation, not your own shortened version.

Note: When in doubt, spell it out.

Objective 8

Purposes of symbols on maps

a. To represent the location and identity of land features that are generally too large to be shown in detail on the map.

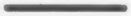
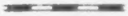
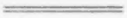
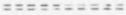
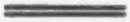
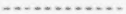
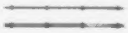
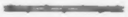
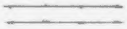
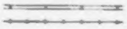
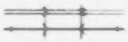
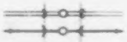
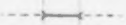
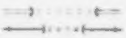
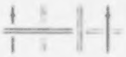
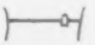
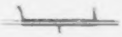
b. To help keep information on a map to a minimum and thereby avoid cluttering.

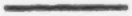
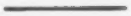
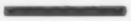
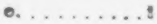
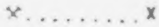
Note: The purpose of the map dictates the types of symbols used.

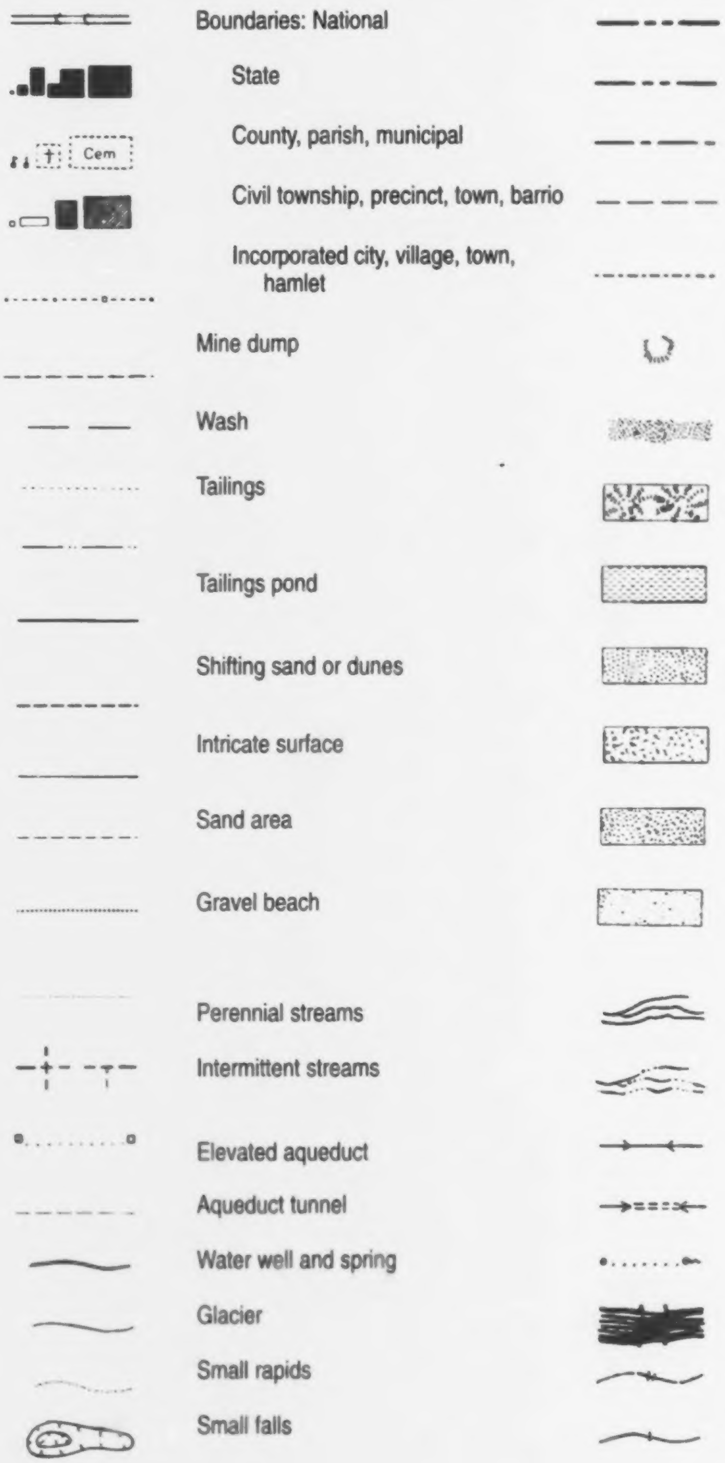
Objective 9

USGS topographic map symbols

Note: Variations will be found on maps.

Primary highway, hard surface	
Secondary highway, hard surface	
Light-duty road, hard or improved surface	
Unimproved road	
Dual highway, dividing strip exceeding 25 feet	
Trail	
Railroad: single track and multiple track	
Railroad in juxtaposition	
Narrow gage: single track and multiple track	
Railroad in street and carline	
Bridge: road and railroad	
Drawbridge: road and railroad	
Footbridge	
Tunnel: road and railroad	
Overpass and underpass	
Small masonry or concrete dam	
Dam with lock	
Dam with road	

Road under construction, alinement known	
Proposed road	
Dual highway, dividing strip 25 feet or less	
Wells other than water (labeled as to type)	○Oil . . . . . ○Gas
Tanks: oil, water, etc. (labeled only if water)	● ● ● ▨Water
Located or landmark object; windmill	
Open pit, mine, or quarry; prospect	
Shaft and tunnel entrance	■. . . . . Y
Horizontal and vertical control station:	
Tablet, spirit level elevation	BM △ 5653
Other recoverable mark, spirit level elevation	△ 5455
Horizontal control station tablet, vertical angle elevation	VABM △ 95/9
Any recoverable mark, vertical angle or checked elevation	△3775
Vertical control station: tablet, spirit level elevation	BM × 957
Other recoverable mark, spirit level elevation	× 954
Spot elevation	× 7369 × 7369



Canal with lock

Buildings (dwelling, place of employment, etc.)

School, church, and cemetery

Buildings (barn, warehouse, etc.)

Power transmission line with located metal tower

Telephone line, pipeline, etc. (labeled as to type)

Reservation, National or State

Small park, cemetery, airport, etc.

Land grant

Township or range line, United States land survey

Township or range line, approximate location

Section line, United States land survey

Section line, approximate location

Township line, not United States land survey

Section line, not United States land survey

Found corner: section and closing

Boundary monument: land grant and other

Fence or field line

Index contour

Intermediate contour

Supplementary contour

Depression contours

Boundaries: National

State

County, parish, municipal

Civil township, precinct, town, barrio

Incorporated city, village, town, hamlet

Mine dump

Wash

Tailings

Tailings pond

Shifting sand or dunes

Intricate surface

Sand area

Gravel beach

Perennial streams

Intermittent streams

Elevated aqueduct

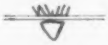
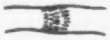
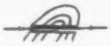
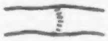
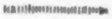
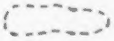
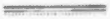
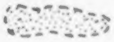
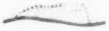
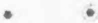
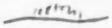
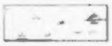
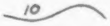
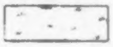
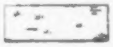
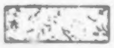
Aqueduct tunnel

Water well and spring

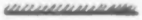
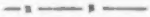
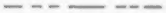
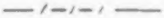
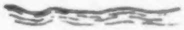
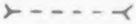
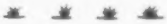
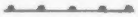
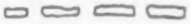
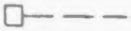
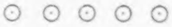
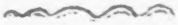
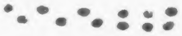
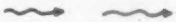
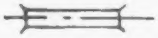
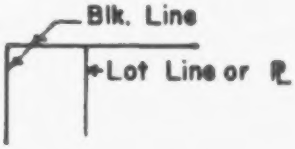
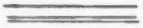
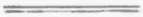
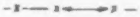
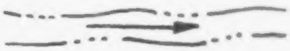
Glacier

Small rapids

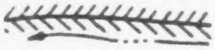
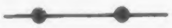
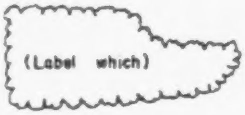
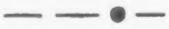
Small falls

Fill		Large rapids	
Cut		Large falls	
Levee		Intermittent lake	
Levee with road		Dry lake bed	
Foreshore flat		Rock, bare or awash; dangerous to navigation	
Rock or coral reef		Marsh (swamp)	
Sounding, depth curve		Submerged marsh	
Piling or dolphin		Wooded marsh	
Exposed wreck		Mangrove	
Sunken wreck			

Objective 10 Other conventional topographic symbols

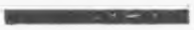
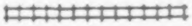
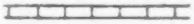
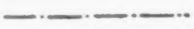
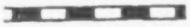
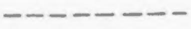
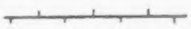
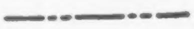
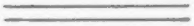
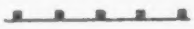
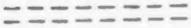
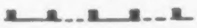
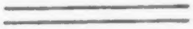
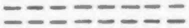
City line		Store	
Fence line		House	
Right-of-way line		Barn	
Limited access line		School	
Shore line		Existing side drain pipe	
Marsh		Proposed fence (limited access)	
Hedge		Inlet (drainage map)	
Trees		Manhole	
Edge of wooded area		High water elevation	H. W. EL.
Shrubbery		Direction of flow	
Bridges over 20 ft. span		Block and lot lines	
Curb and gutter (proposed) dash existing curb and gutter			
Curb (proposed) dash existing curb			
Gate		Creeks and rivers	
Church			

Blk. Line
Lot Line or ℄

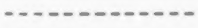
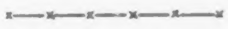
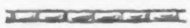
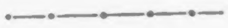
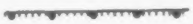
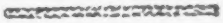
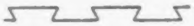
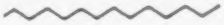
Terraces (ticks pointing down grade)		R/W line and marker in place	
Timber, orchard, brush or nursery		R/W line and marker new	
		Point of intersection (PI)	△
		Principal points along survey ℄	•
		Horizontal control station	

Objective 11 Boundary, fence, and track fixture symbols

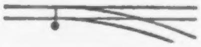
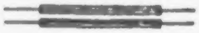
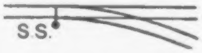
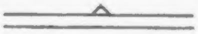
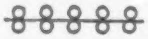
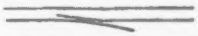
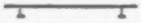
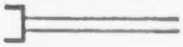
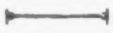
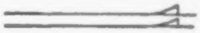
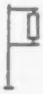
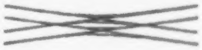
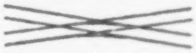
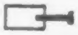
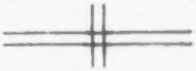
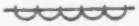
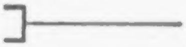
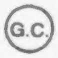
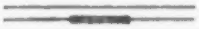
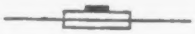
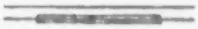
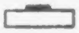
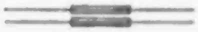
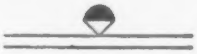
a. Details of railways, boundary and survey lines

Steam		Foreign Track (Show rd. initials) (color other than red or black)	
Electric		Foreign R. of W. Line	
Street Rwy		Center line	
Narrow gauge		Company R of W (property line)	
Present track to remain		Fence on street	
Present track to be removed		Fence on Rwy property line	
Proposed track (Red)			
Proposed future track (Red)			

b. Fences

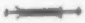
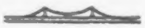
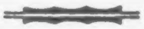
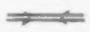
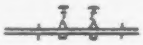
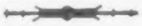
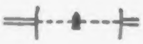
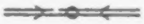
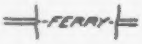
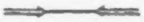
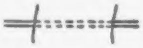
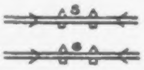
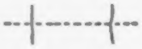
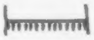
Board fence or fence in general		Barbed wire fence	
Stone fence		Smooth wire fence	
Picket fence		Hedge fence	
Rail fence		Worm fence	

c. Details of track fixtures and accessories

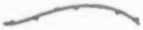
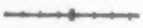
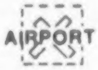
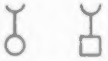
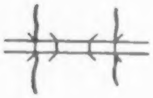
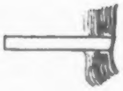
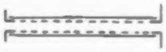
Turnout and switch stand		Double car retarder	
Spring switch		Electric light	
Detail (block)		Flood lighting tower	
Derail (Switch pt.)		Rail rest	
Bumping post		Gantry crane	
Friction car stop		Mail crane	
Double slip sw.			
Single slip sw.		Boom crane	
Crossing		Track pan	
Bumping post		Gas container	
Single car retarder		Track scale	
Double car retarder		Stock scale	
Single car retarder		Rail lubricator	

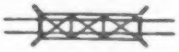
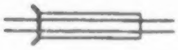
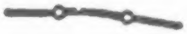
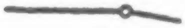
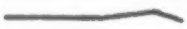
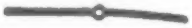
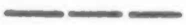
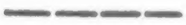
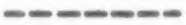
Objective 12 Civil symbols

a. On plan sheets

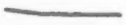
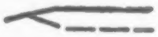
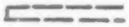
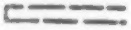
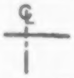
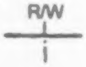
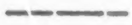
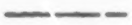
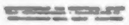
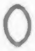
Bridge–general symbol, R.R.		Suspension bridge	
		Arch bridge	
Bridge–general symbol, hwy		Pontoon bridge	
Drawbridge–R.R.		Ferry	
Drawbridge–hwy		Ferry	
Footbridge		Ford road	
Truss bridge (W, wood; S, steel; G, girder		Ford trail	
		Dam	

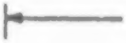
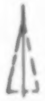
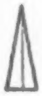
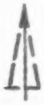
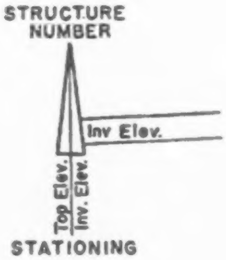
Information Sheet

Telephone or telegraph line	T T T T T T
Telephone line	
Railroad station of any kind	
Airport	
Mosque	
Lift bridge	
Pier	
Tunnel	

Truss	
Girder	
Const. center line	
Present ctr. line	
Profile grade	
Ground line	
Subcut	
Ditch grade rt.	
Ditch grade lt.	

b. On cross section sheets

Ground line	
Const. cross section subcut	
Culvert inp.	
New culvert	
Center line	
Right of way	
Entrance	
Ditch block	
Water	
Existing pipes or culverts	
Proposed pipes or culverts	

Dimension line	
Existing manhole	
Proposed manhole	
Future manhole	
Structure number stationing	 STRUCTURE NUMBER Inv Elev. Top Elev. Inv. Elev. STATIONING

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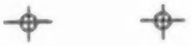
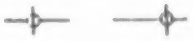
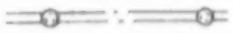
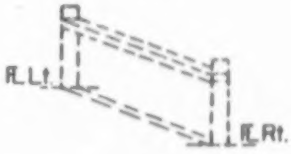
Objective 13 Utility and service symbols

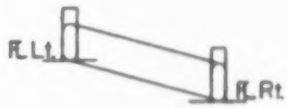
Note: Give number of wires, owner's name, and address.

Overhead power (cross bar perpendicular to ℄)	ϕ ϕ
Overhead telephone (cross bar parallel to ℄)	-⊖- -⊖-
Joint ownership poles	
Power or telephone overhead (when line crosses ℄)	
Power underground	—P·U G—
Telephone underground	—T·U.G—
Power manhole	Ⓟ
Telephone manhole	Ⓣ
Oil line	— O — O —
Water line	— W — W —
Gas line	— G — G —
Water meter	o— W. M.
Gas meter	o— G. M.
Fire hydrant	o— F. H.
Valve	
Water well	◎
Storm sewer and manhole	
Sanitary sewer	→S.S. →S.S. → (size and type)

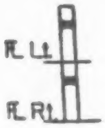
Exist. skew box



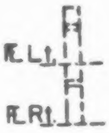
New skew pipe



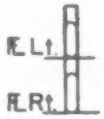
New 90° box



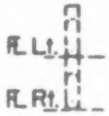
Exist. 90° box



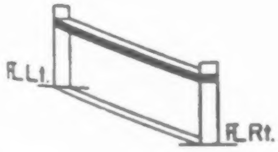
New 90° pipe



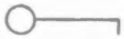
Exist. 90° pipe



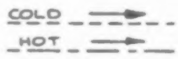
New skew box



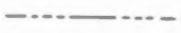
Water column



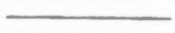
Water pipes



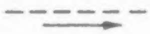
Refrigerant pipe

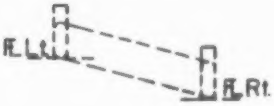
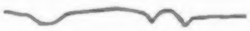
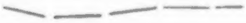
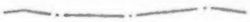
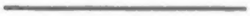
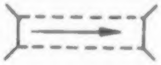
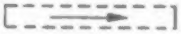
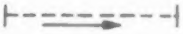
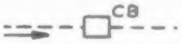
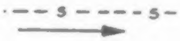
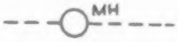
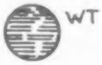


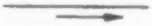
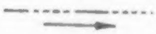
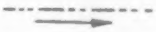
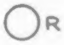
Gas pipe



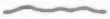
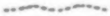
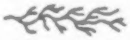
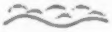
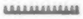
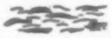
Condensate pipe

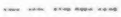
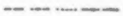
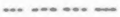
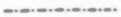
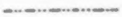
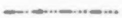
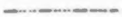
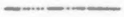
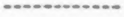


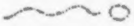
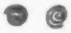
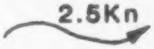
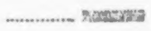
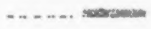
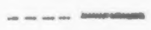
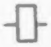
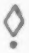
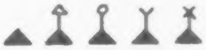
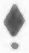
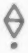
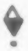
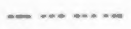
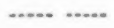
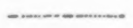
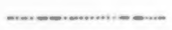
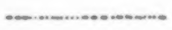
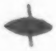
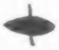
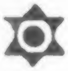
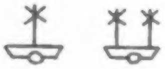
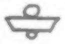
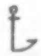
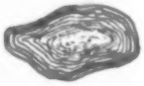
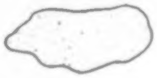
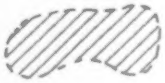
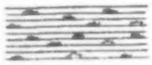
Exist. skew pipe	
Exist. ℄ ground line	
Exist. ground line rt.	
Exist. ground line lt.	
New profile grade line	
Arch or flat T masonry culvert	
Pipe in excess of 36″	
Drain pipe	
Catch basin	
Sewer line	
Manhole	
Water tank	

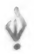
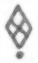
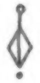
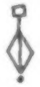
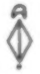
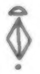
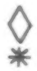
Steam pipe	
Oil pipe	
Compressed air pipe	
Riser	

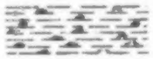
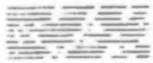
Objective 14 Hydrographic and navigation symbols

Surveyed shore line	
Unsurveyed shore line	
Kelp or eel grass	
Rock underwater	
Rock awash	
Breakers along shore	
Fishing stakes	
Overfalls and tide rips	

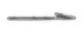
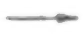
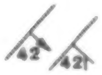
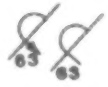
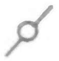
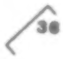
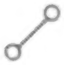
4 fathom line	
5 fathom line	
6 fathom line	
10 fathom line	
20 fathom line	
30 fathom line	
40 fathom line	
50 fathom line	
100 fathom line	

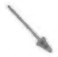
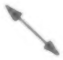
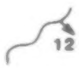
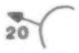
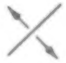
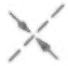
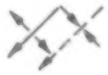
Limiting danger line	
Whirlpools and eddies	
Cable	-------
Non-tidal current 3 knots	⋙ 3Kn →
Non-tidal current (special use)	 2.5Kn
Tidal currents flood 2 knots	2Kn →
Tidal current ebb 1 knot	1Kn →
Tidal current flood 2nd hour	●● →
Tidal currents ebb 3rd hour	●●● →
No bottom at 100 fathoms	$\frac{\bullet}{100}$
DEPTH CURVES	
1 fathom or 6 foot line	
2 fathom or 12 foot line	
3 fathom or 18 foot line	
Radio tower	RT ⊙
Radio beacon	RBn ⊙
Water gage	
Lighted beacon	
General or red buoy	
Not lighted beacon	
Black buoy	
Horizontal striped buoy	
Horizontally striped (black & red) buoy	
200 fathom line	-- -- -- --
300 fathom line	
400 fathom line	
500 fathom line	
1000 fathom line	
2000 fathom line	
3000 fathom line	
Life saving station	 LSS
Coastguard life safety station	 CG
Lighthouse	
Lighthouse (smaller scale)	●
Light vessels	
Radio station	RS ⊙
Radio compass station	RC ⊙
Mooring buoy	
Anchorage	⚓
Small vessel anchorage	
Pond	
Salt pond	
Intermittent pond	
Salt marsh	

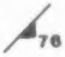
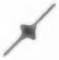
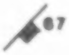
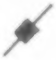
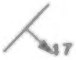
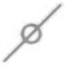
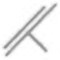
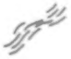
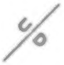
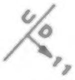
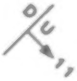
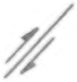
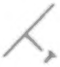
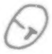
Vertically striped buoy	
Checkered buoy	
Perch & ball buoy	
Perch & square buoy	
Whistling buoy	
Bell buoy	
Lighted buoy	

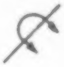
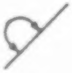
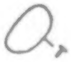
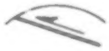
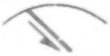
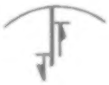
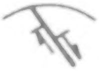
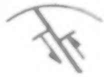
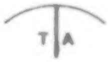
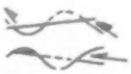
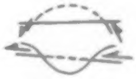
Fresh marsh	
Tidal flat	

Objective 15 Geological structure symbols

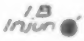
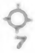
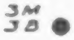
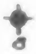
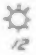
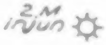
Direction	
Altitude	
Strike & dip of beds (arrow used in detailed maps)	
Strike & dip of overturned beds	
Strike of vertical beds	
Horizontal beds	
Strike & dip of cleavage (slate)	
Strike of vertical cleavage (slate)	
Horizontal cleavage (slate)	

Direction of pitch of linear parallelism, flow lines, linear stretching, or alignment of minerals & inclusions	
Direction of horizontal linear element	
General strike & dip of minutely folded beds	
Direction of pitch of minor folds (nature of isoclinal fold at its plunging end)	
Axis of anticline	
Axis of syncline	
Pitch of axis of anticline or syncline	

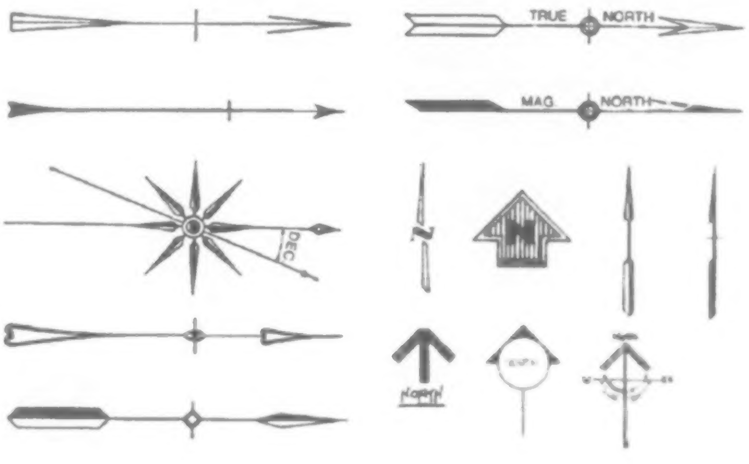
Strike & dip of schistosity or foliation	
Strike of vertical schistosity or foliation	
Horizontal schistosity	
Strike & dip of joint plane	
Strike of vertical joint plane	
Horizontal joint plane	
Concealed fault covered by later deposits (known or hypothetical)	-------
Dip of fault plane	
Vertical fault plane	
Shear zone strike & dip	
Shear zone	
U-upthrow, high-angle fault, D-downthrow, high angle fault	
Normal fault	
Reverse fault	
Direction of horizontal movement in shear fault, tear fault, or flaw	
Overthrust, low-angle fault; T, over-thrust side	
Klippe or outlier remnant of low angle fault plate; T, overthrust side	

Axis of overturned or recumbent anticline (showing direction of inclination of axial plane	
Axis or overturned or recumbent syncline (showing direction of inclination of axial plane)	
Known fault	———
Known fault (approximate location)	- - - -
Doubtful or hypothetical fault	—?—?—
Window, fenster, or hole in overthrust plate; T, overthrust side	
Overthrust; low-angle fault fault; arrow is directional movement of active block	
Underthrust; low-angle fault; arrow is directional movement of active block	
Vertical; high angle fault (arrow shows directional movement)	
Normal fault; high angle fault (arrow shows directional movement)	
Reverse fault; high angle fault (arrow shows directional movement)	
Horizontal movement in shear or tear fault (A-movement away from observer, T-movement toward observer)	
Klippe	
Window or fenster	

Objective 16 Oil and gas symbols

Location, rig or drilling well	
Location, rig or drilling well, abandoned	
Location, rig or drilling well, number	
Oil well	
Small oil well, abandoned	
Small oil well, number	
Small oil well, volume	
Salt well	
Dry hole	
Dry hole, abandoned	
Dry hole, number	
Dry hole with showing of oil	
Oil well, abandoned	
Oil well, number	
Oil well, volume	
Small oil well	
Dry hole with showing of oil, abandoned	
Dry hole with showing of oil, number	
Gas well	
Gas well, abandoned	
Gas well, number	
Gas well, volume	
Gas well with showing of oil	
Gas well with showing of oil, abandoned	

Objective 17 North arrow symbols



Objective 18

General rules for drawing map symbols

a. Should be easy to read and understand

b. Should conform to the general design and purpose of the drawing

c. Should follow standard and acceptable formats

d. Should assume as much as possible the form of the actual object it represents

e. Should never crowd a map

Example: Too many symbols for grass

f. Number of symbols included on a map is limited by the scale of the map.

g. Regardless of the scale of the map, symbols are drawn essentially the same size. They must be large enough for reproduction at present and final scale.

Note: It is the judgment of the civil drafter and engineer to enlarge or emphasize the symbol according to priority of information shown on the map.

h. Prominence of a symbol over another is achieved by variation in the line weight of the symbol or shading of the symbol.

Note: The purpose of the map will determine which symbol is made prominent.

i. Symbols repeated on a map need to be drawn identical to each other.

j. For all symbols that have a definite base such as grass and marsh, this base should be drawn parallel to the bottom of the sheet. (Never parallel to roadway and streams.)

k. Good rule to follow in proportioning a map would be to draw the important symbols first and work toward the least important features.

Objective 19

Methods used in drawing symbols

a. Freehand, such as woods, streams, material symbols

b. Template for specific mapping symbols

c. Stick up sheets

d. Pressure-sensitive transfers

e. CAD—Use of menu symbols to place repetitive symbols

Information Sheet

Objective 20

Colors of map symbols

a. Black—Cultural features, boundaries, lettering and notations

b. Blue—Water features such as seas, oceans, lakes, rivers, and canals; dark blue may be used for drainage systems

c. Brown—Contours, sand, washes, and topographic relief

d. Green—Vegetation such as trees, shrubs, orchards, and vineyards

e. Yellow—Additional boundaries and distributional tones

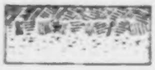
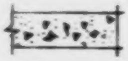
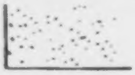
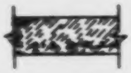
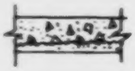
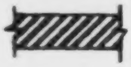
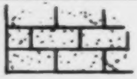
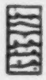
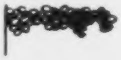
f. Red—Important roads, public land and land grants, subdivisions, and field lines

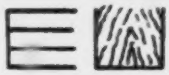
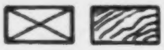
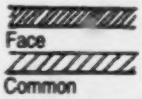
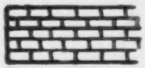
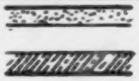
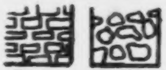
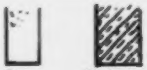
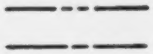
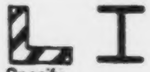
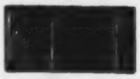
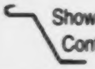
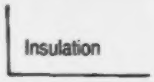
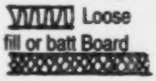
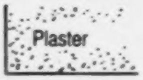
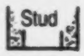
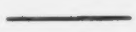
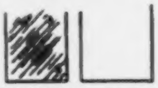
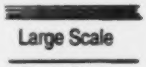
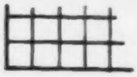
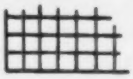
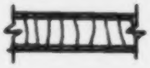
g. Gray—Shading and hatch marks

h. Purple—Office revisions from aerial photographs

Objective 21

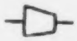
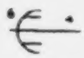
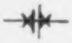
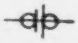
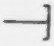
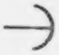
Common material symbols used in structural and architectural drawings

MATERIAL	PLAN	ELEVATION	SECTION
Earth	None	None	
Plain concrete			Same as plan view
Concrete reinforced with bars			Same as plan view
Concrete reinforced with mesh			Same as plan view
Concrete block			
Gravel Fill	Same as section	None	

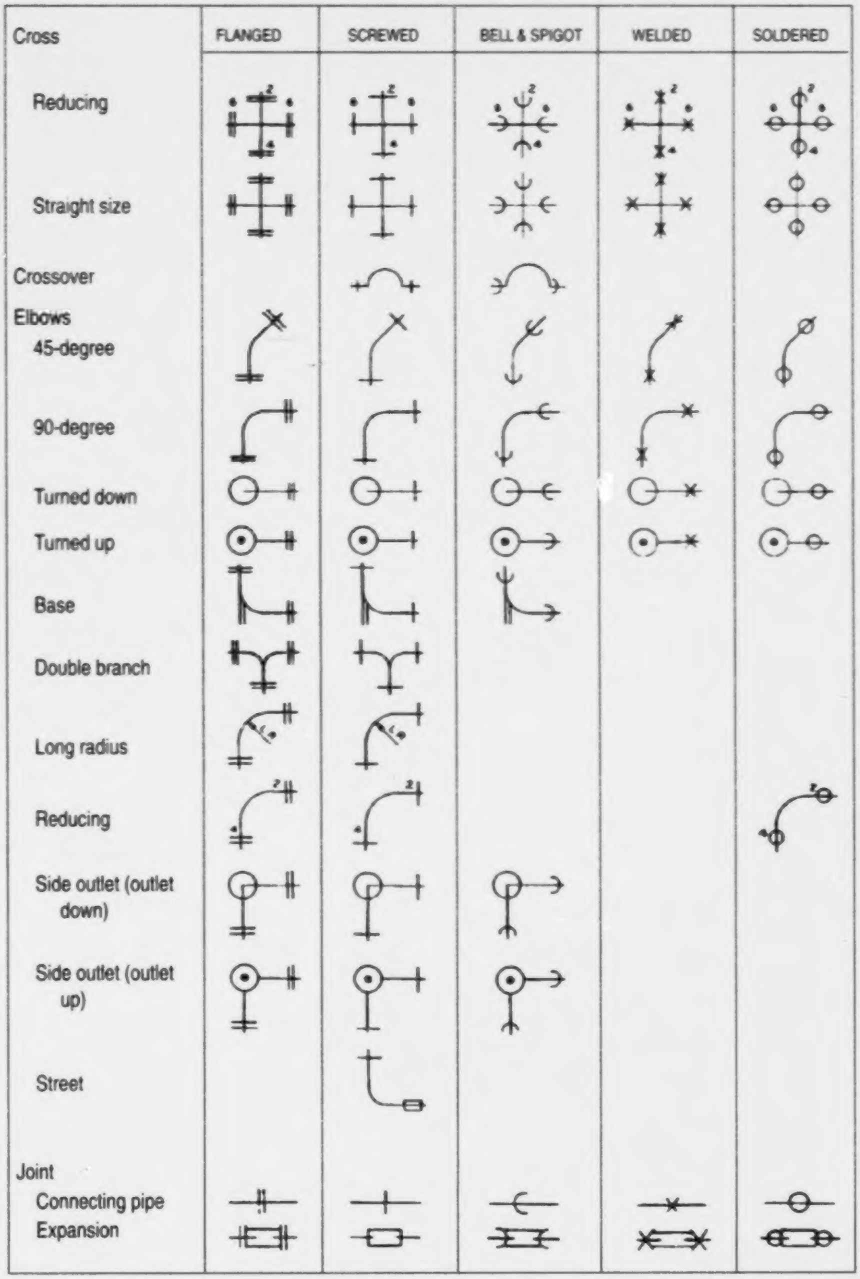
MATERIAL	PLAN	ELEVATION	SECTION
Wood	Floor areas left blank		
Brick	 Face Common	 Face or common	Same as plan view
Stone		 Cut Rubble	 Cut Rubble
Structural Steel		Indicate by note	 Specify
Sheet metal Flashing	Indicate by note		 Show Contour
Insulation	Same as section	 Insulation	 Loose fill or batt Board
Plaster	Same as section	 Plaster	 Stud Lath and plaster
Glass			 Large Scale Small Scale
Tile			

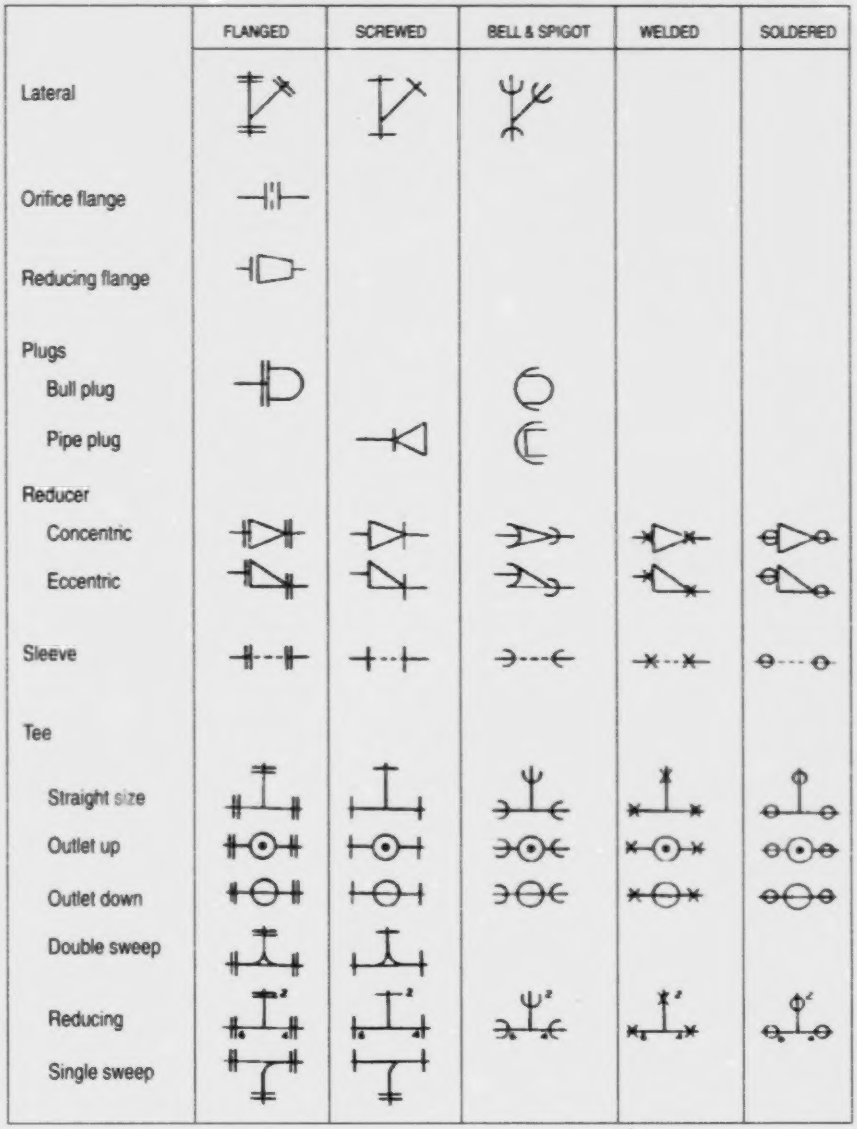
Objective 22

Standard symbols for pipe fittings

	FLANGED	SCREWED	BELL & SPIGOT	WELDED	SOLDERED
Bushing					
Cap					

577


Cross
FLANGED
SCREWED
BELL & SPIGOT
WELDED
SOLDERED
Reducing
Straight size
Crossover
Elbows
45-degree
90-degree
Turned down
Turned up
Base
Double branch
Long radius
Reducing
Side outlet (outlet down)
Side outlet (outlet up)
Street
Joint
Connecting pipe
Expansion


FLANGED
SCREWED
BELL & SPIGOT
WELDED
SOLDERED
Lateral
Orifice flange
Reducing flange
Plugs
Bull plug
Pipe plug
Reducer
Concentric
Eccentric
Sleeve
Tee
Straight size
Outlet up
Outlet down
Double sweep
Reducing
Single sweep

Student Supplement 1—Abbreviations of Commonly Used Words in Civil Drafting

Note: These are used on maps and drawings as labels.

A

Abandoned	ABD
Abbreviations	ABBR
Above	ABV
Abutment	ABUT
Access	ACC
Acre	AC
Acre-foot	AC-FT
Addition	ADD.
Adjusting, adjacent	ADJ
Afternoon	PM
Aggregate	AGG
Alternate, altitude	ALT
Aluminum	AL
American Concrete Institute	ACI
American Institute of Steel Construction	AISC
American National Standards Institute	ANSI
Anchor	AHR
Anchor bolt	AB
Angle	Angle
Approach	APPR
Approved	APPD
Approximate	APPROX
Apron	APR
Area	A
Area drain	AD
Article	ART
Asbestos	ASB
Asbestos cement, asphaltic concrete	AC
Asphalt	ASPH
Assembly	ASM
Assistant	ASST
Associate	ASSOC
Association	ASSN
Automatic	AUTO
Auxiliary	AUX
Avenue	AVE
Average	AVG
Avoirdupois	AVDP
Azimuth	AZ

B

Background	BKGD
Backsight	BS
Back to back	B to B
Barbed wire	BW
Barrel	BBL
Baseline	BL or $\overset{B}{L}$
Basement	BSMT
Bearing	BRG
Bearing value	BV
Begin	BEG
Beginning of project	BOP
Bell and spigot	B & S
Below	BLW
Bench mark/Beam	BM
Between	BETW
Beveled	BEV
Bituminous	BIT
Bituminous coated corrugated metal pipe culvert	BCCMP
Bituminous coated and paved corrugated metal pipe culvert	BCPCMP
Bituminous coated pipe arch culvert	BCPA
Bituminous coated and paved pipe arch culvert	BCPPA
Black/block	BLK
Board	BD
Board feet	FBM
Bolt	BLT
Bottom	BOT
Boulders	B
Boulevard	BLVD
Boundary	BNDY/BDY
Bridge	BR
Brook	Brook
Brown	BRN
Building	BLDG
Built-up	B/U
Bulkhead	BLKHD
Bureau of Public Roads	BPR
Bushel	BU
Butterfly valve	BV

C

Capacity	CAP
Capital	CAP
Cast iron	CI
Cast iron pipe	CIP
Cast iron soil pipe	CISP
Catch basin	CB
Ceiling	CLG
Cement, Cemetery	CEM

Student Supplement 1

Centerline	CL
Center	CTR
Centers	CTRS
Center to center	C to C
Centimeter(s)	CM
Chain	CH
Change	CHG
Channel	Channel
Checked	CKD
Church	CH
Circular	CIR
Clay	CL
Clear, clearance	CLR
Cleanout	CO
Coated	CTD
Coefficient	COEF
Column	COL
Computations	COMP
Concrete	CONC
Concrete cylinder pipe	CCP
Concrete masonry units	CMU
Concrete pipe	CP
Connection	CX, CONN
Construction	CONST
Construction joint	CJ
Continuation	CONT
Continuous	CONT
Continued	CONTD
Contract	CONT
Contract limit line	CCL
Contractor	CONTR
Contraction	CONTR
Control	CONT
Control of access	C of A
Coordinate	COORD
Corner	COR
Corrugated iron	CORR I
Corrugated metal	CM
Corrugated metal pipe	CMP
Corrugated metal pipe arch culvert	CMPA
County	CO
County road	CO RD
Creek	CR
Cross road	X RD
Cross section	X SECT
Cubic	CU
Cubic foot	CF
Cubic feet per minute	CFM
Cubic feet per second	CFS
Cubic yard	CY
Culvert	CULV
Curb and gutter	C&G
Curve to spiral	CS
Cylinder	CYL

D	
Degree	DEG
Degree of curvature	D
Delta	Delta
Demolish, demolition	DEM
Department	DEPT
Depressed	DEP
Designed	DSGN
Diagonal	DIAG
Diameter	D or DIAM
Dimension	DIM
Directional	DIR
Distance	DIST
Down	DN
Drawn	D or DR
Drawing	DWG
Drawings	DWGS
Drop inlet	DI
E	
Each	EA
Each face	EF
Each way	EW
East	E
Elbow	ELL
Electric(al)	ELEC
Electronic distance meter	EDM
Elevation (above sea level)	EL
Elevation (view)	ELEV
Emergency	EMERG
Enclosure	ENCL
End of project	EOP
End to end	E to E
End vertical curve	EVC
Engineer	ENGR
Engineering	ENGG
Equal	EQ
Equally spaced	EQL SP
Equation	EQ
Equipment	EQPT
Equivalent	EQUIV
Estimate	EST
Excavation	EXC
Existing	EXST
Expansion	EXP
Expansion joint	EXP JT
Extension, Exterior, External	EXT
External distance	E
Extra	Extra
F	
Face of concrete	FOC
Face to face	F to F
Federal	FED
Federal Aid	FA
Federal Aid Interstate	FAI

Federal Aid Primary, Federal Aid Project	FAP
Federal Aid Secondary	FAS
Feet	FT
Feet board measure	FBM
Feet per minute	FPM
Feet per second	FPS
Ferry	FY
Field Book	FB
Figure	FIG
Finish grade	FG
Fire hydrant	FH
Flange, flanged	FLG
Flexible	FLEX
Floor, floor line, flow	FL
Floor cleanout	FCO
Floor drain	FD
Flow line	FLL
Flush hole	FH
Foot	FT
Footing	FTG
Ford	FD
Forenoon	AM
Foresight	FS
Foundation	FDN
Frontage road	FNTG RD
Full size	FS
Future	FUT

G

Gage	GA
Gallon	GAL
Gallons per minute	GPM
Gallons per second	GPS
Galvanized iron	GI
Gate valve	GTV
General	GENL
Granite	GRN
Gravel	GVL
Green	GRN
Grid north	GN
Ground	GRD/GND

H

Handrail	HR
Header	HDR
Height	HGT
Height of instrument	HI
Hexagonal	HEX
High water	HW
Highway	HWY
Horizontal	HORiZ
Horsepower	HP
Hose bib	HB
Hour	HR
House	HSE or H
Hub drain	HD

I

Inch	IN
Including	INCL
Incorporated	INC
Information	INF
Influent	INFL
Inside diameter	ID
Inside face	IF
Installation	INSTL
Interlock	ILK
Intermediate	INTER/INTM
Interstate highway	IH
Iron pipe, iron pin	IP
Invert	INVT
Invert elevation	IE

J

Joint	JT
Junction	JNCT/JCT/JT
Junction box	JB

L

Lake	Lake
Lateral	LATL
Latitude	LAT
Left	LT
Length	LGTH
Length of curve	L
Length of tangent	T
Light	LT
Lighting	LTG
Limestone	LMS
Linear	LIN
Linear foot	LIN FT
Longitude, Longitudinal	LONG
Low point	LPT
Low water	LW

M

Manhole	MH
Material	MTL
Maximum	MAX
Mean sea level	MSL
Median	MED
Membrane	MMB
Meridian	MER
Mile	MI
Miles per hour	MPH
Millimeter(s)	MM
Minimum, Minute	MIN
Miscellaneous	MISC

N	
National	NATL
National Geodetic Survey	NGS
Negative	NEG
Nominal	NOM
North	N
Northeast	NE
Northwest	NW
Not applicable	NA
Not to scale	NTS
Number	NO
Numbers	NOS
O	
Obscure	OBS
On center	OC
Opening	OPNG
Opposite	OPP
Orange	ORN
Original	ORIG
Ounce	OZ
Outside diameter	OD
Outside face	OF
Outside to outside	O to O
Overall	OA
P	
Page	P
Pages	PP
Paragraph, Parallel	PAR
Parking	PK
Piling	PLG
Piping	PP
Plan and profile sheet	P&P SHEET
Pave(d)(ing)	PV
Pavement	PVMIPAVT
Plane	PL
Plate, property line	PL
Point	PT
Point of beginning	POB
Point of compound curvature	PCC
Point of curvature	PC
Point of intersection	PI
Point of reverse curve	PRC
Point of tangency	PT
Point on curve	POC
Point on tangent	POT
Polyvinyl chloride	PVC
Portland cement concrete	PCC
Pound	LB
Pounds per square inch gauge	PSIG
Power	PWR
Power pole	PP
Precast	PRCST
Pressure	PRES

Pressure reducing valve	PRV
Primary	PRI
Principal meridian	PRIN MER
Project	PROJ
Q	
Quadrangle	QUAD
Quart	QT
R	
Radius	R or RAD
Railroad	RR
Railway	RY
Rain drain, roof drain	RD
Range	R
Received	RECD
Reduction	REDUC
Reference	REF
Reference point	RP
Reflector	REFL
Regular	REG
Reinforced	REINF
Reinforced concrete	RC
Reinforced concrete pipe	RCP
Reinforcement, reinforcing	REINF
Remove	RMV,REM
Replace	REPL
Required	REQD
Reverse	RVS
Revision	REV
Right	RT
Right lane	RT LN
Right-of-way	R/W, ROW
River	R
Road	RD
Roadway	RDY
Round	RD
Route	RTE
S	
Sanitary sewer	SAN S
Schedule	SCH, SCHED
Second	SEC
Secondary	SECD
Section	SECT
Section line	SL or $\overset{S}{L}$
Separate	SEP
Service	SERV
Sheet	SH
Shore(d)(ing)	SHO
Signal	SIG
South	S
Southeast	SE
Southwest	SW
Special	SPL
Specification(s)	SPEC

Spillway	SPLWY
Spiral to curve	SC
Spiral to tangent	ST
Square	sa
Square foot	SQ FT
Square inch	SQ IN
Square mile	SQ MILE
Square yard	SQ YD
Standard	STD
State	State
State Aid Project	SAP
State highway	SH
State work order	SWO
Station	STA
Steel	STL
Storm sewer	SS
Straight, Stream	STR
Street	ST
Structure, Structural	STR
Submerged	SUBMG
Substructure	SUBSTR
Superstructure	SUPERSTR
Support	SUP
Survey	SURV
Symmetrical	SYM
System	SYS

T

Tangent	TAN/T
Telegraph	TELG
Telephone	TELP
Telephone pole	TP
Temperature, temporary	TEMP
Temporary benchmark	TBM
Terminal	TERM
Terra cotta	TC
Thick	THK
Thickness	THKNS
Thousand	M
Tolerance	TOL
Tongue and groove	T&G
Top and bottom	T&B
Top face	TF
Top of	TO
Top of concrete	TC
Top of steel	TST
Top of wall	TW
Topography	TOPO
Township	TWP/T
Transom	TR
Transverse	TRANSV
True north	TN
Turning point	TP
Typical	TYP

U

Undercut	UC
Underground	UG
Upstream	UPSTR
U.S. Geological Survey	USGS
U.S. Coast & Geodetic Survey	USC & GS

V

Variable	VAR
Vertical	VERT
Vertical curve	VC
Vertical grain	VG
Volume	VOL

W

Water surface, waterstop, welded steel	WS
Water tank, Weight	WT
West	W
White	WHT
With	W/
Without	W/O
Working point	WP

Y

Yard	YD
Year	YR
Yellow	YEL

Objective 23

Assignment Sheet 1—Set Up a Map Legend

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Neatness and overall presentation	______
• Correctness of symbols	______

Basic Skills

Reading

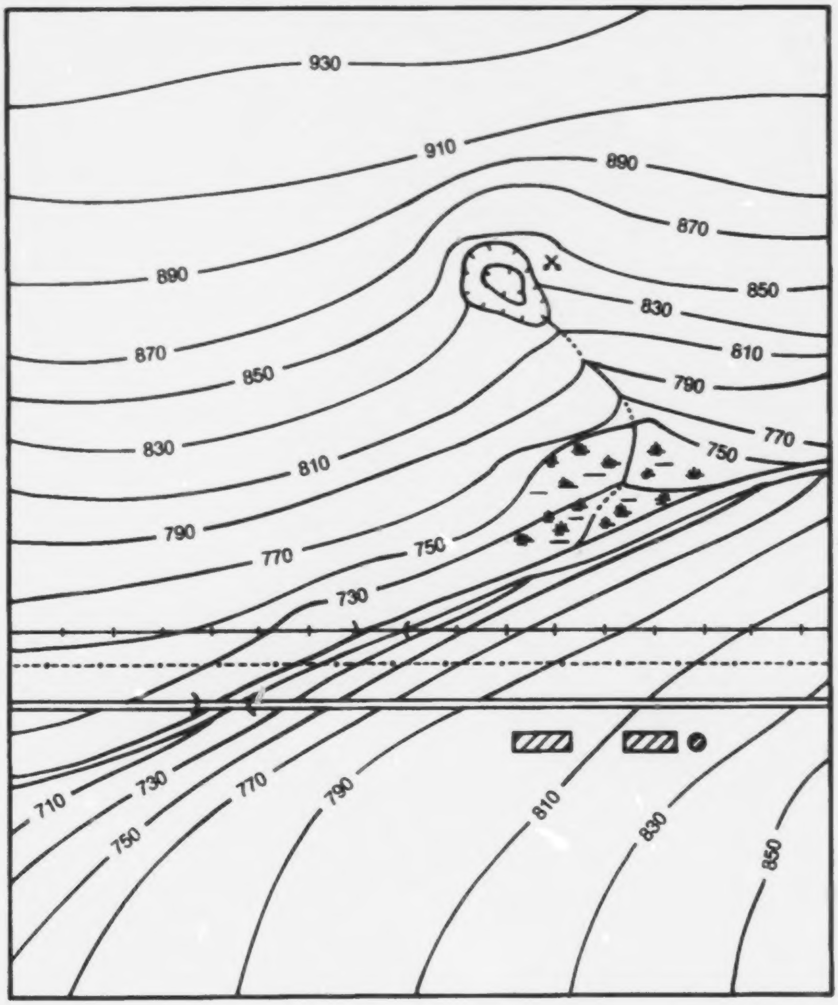
Critical Thinking

Directions

Using the provided topographic map, find the symbol used to describe features and set up a legend for the map on reverse side of the page. Ask your instructor for the size of paper and tools to use (pencil or ink).

Assignment Sheet 1

Suggested format: 8½" x 11" film, ink, and Leroy lettering.


930
910
890
870
890
850
830
870
850
810
790
830
810
770
750
790
770
750
730
710
730
750
770
790
810
830
850

586

Objective 24

Assignment Sheet 2—Locate and Identify Symbols and Features on a USGS Map

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Correct identification of symbols	______
• Assignment is neat and legible	______

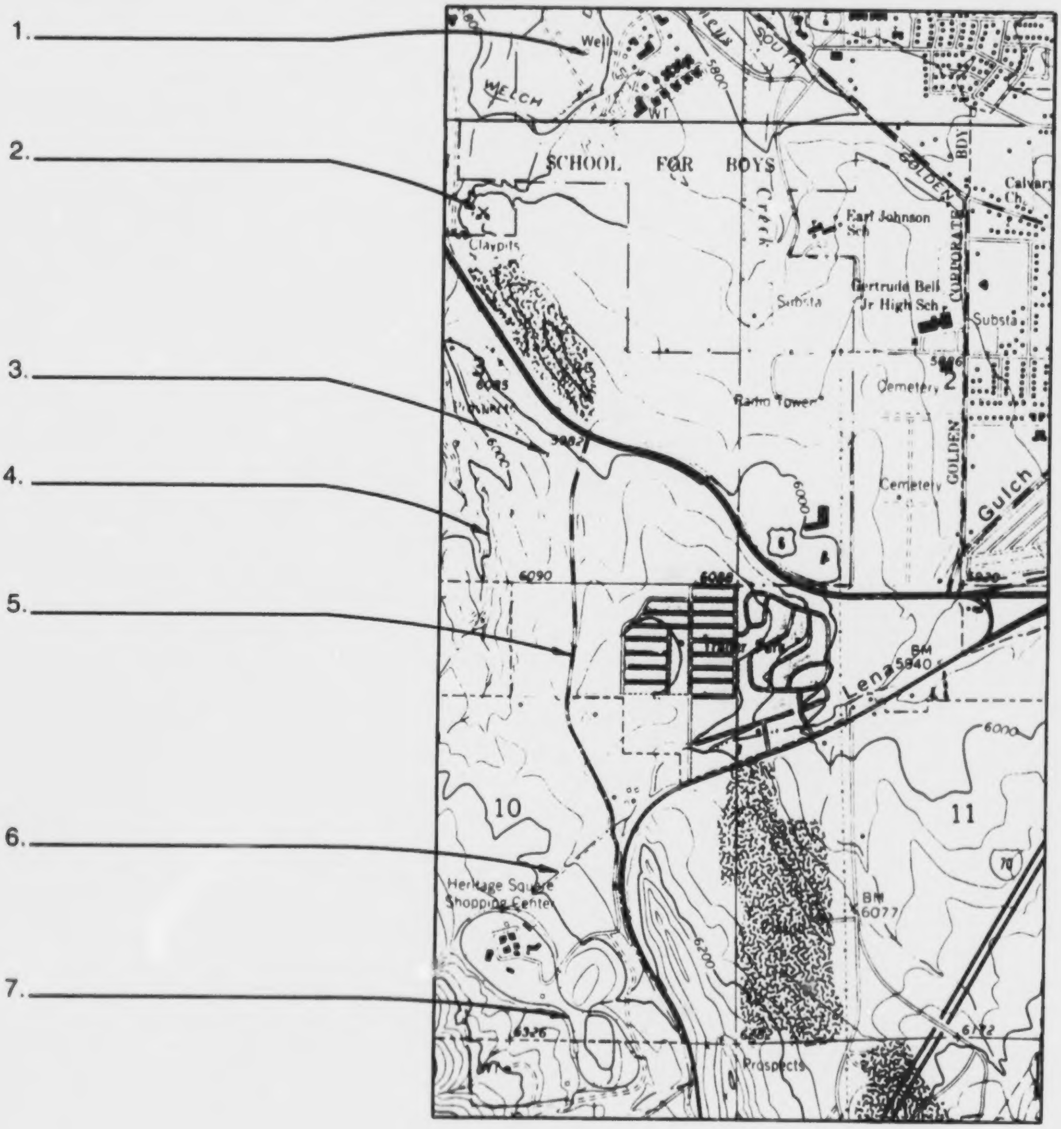
Basic Skills

Reading Critical Thinking

Directions

Identify each symbol called for on the portion of the USGS 7.5-minute quadrangle map shown on the following pages.

Assignment Sheet 2


Well
WELCH
5800
SCHOOL FOR BOYS
Creek
Earl Johnson Sch
Calvary Ch
GOLDEN
CORPORATE BDY
Claypits
Gertrude Bell Jr High Sch
Substa
Substa
Radio Tower
Cemetery
Cemetery
2
3
6000
Gulch
6090
6086
Trailer Park
BM 5840
Lena
10
11
70
Heritage Square Shopping Center
BM 6077
6200
6336
Prospects
6172

1. ____________________

2. ____________________

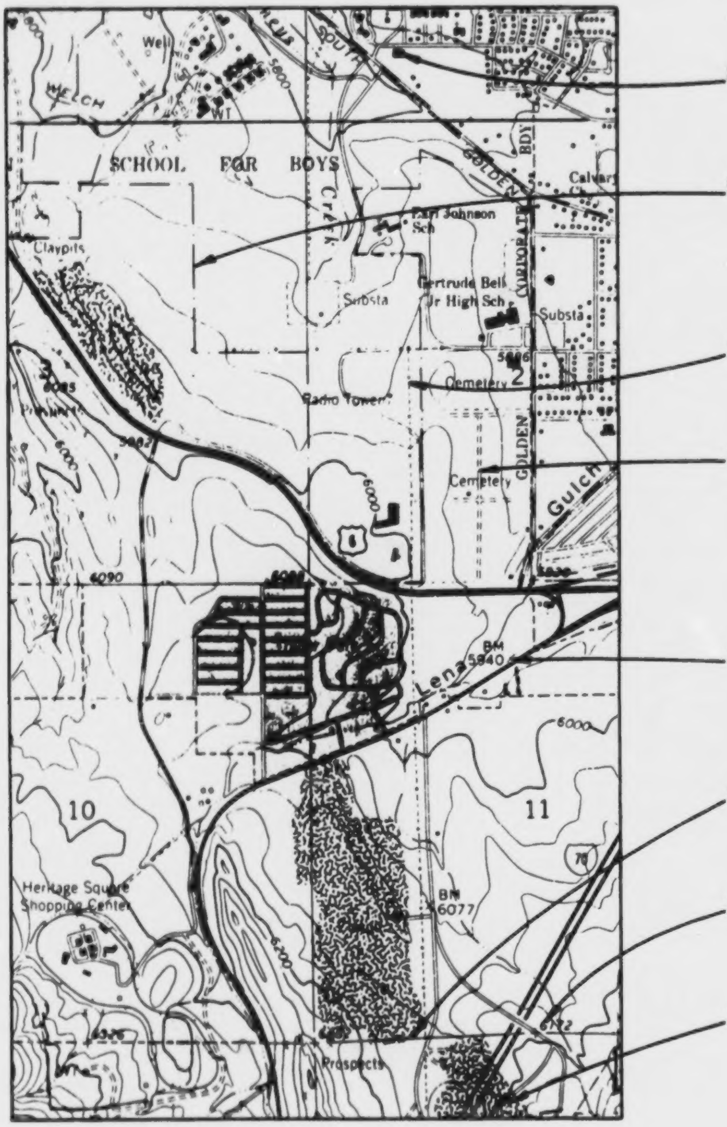
3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________


Well
WELCH
WT
SCHOOL FOR BOYS
Creek
Claypits
Earl Johnson Sch
Gertrude Bell Jr High Sch
Substa
Substa
GOLDEN
CORPORATE BDY
Calvary
Radio Tower
Cemetery
2
Cemetery
Gulch
6000
6090
BM 5840
Lena
6000
10
11
70
Heritage Square Shopping Center
BM 6077
6200
Prospects
WT

8. ____________________

9. ____________________

10. ____________________

11. ____________________

12. ____________________

13. ____________________

14. ____________________

15. ____________________

Unit 5

Map Projections, Reference Systems, and Legal Land Descriptions

Unit Contents

Student Components

Student Page

Objective Sheet 5–3

Information Sheet 5–5

Student Supplements

1—Principal Meridians and Base Lines 5–21
2—U.S. Public Land Survey System 5–23
3—Lot and Block Description 5–25
4—Typical Metes and Bounds Descriptions 5–27
5—Sample Plat 5–29
6—State Plane Coordinate Grid Systems 5–31
7—Metric Coordinate Reader 5–33

Assignment Sheets

1—Answer Questions Based on the U.S. Public Land Survey System 5–35
2—Write and Locate Descriptions for the Subdivision of a Section 5–37
3—Write a Lot and Block Description 5–43
4—Identify Components Used to Develop a Plat 5–45
5—Identify Geographic Coordinates on a USGS Quadrangle Map 5–47
6—Scale on a UTM Grid 5–49

Map Projections, Reference Systems, and Legal Land Descriptions

Objective Sheet

Unit Objective

After completing this unit, the student should be able to describe land parcels by the U.S. system of rectangular surveys, metes and bounds, and the lot and block method, and identify geographic coordinates on a USGS quadrangle map. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to map projections, reference systems, and legal land descriptions with their definitions.
2. Define the concepts that are fundamental to map projections and reference systems.
3. Select true statements concerning factors in the selection of a map projection.
4. Match projections used by the USGS with their definitions.
5. Match methods of legal land descriptions with their definitions.
6. Select true statements concerning coordinate systems.
7. Complete statements concerning the U.S. public land survey system.
8. Complete statements concerning the subdivision of a section.
9. Complete statements concerning lot and block descriptions.
10. Select true statements concerning metes and bounds descriptions.
11. List the components used to develop a plat.
12. Complete statements concerning state plane coordinates.
13. Match common legal aspects of land acquisition with their definitions.
14. List the six types of boundary classifications.
15. Arrange in order the precedence for boundary rank of types of boundary units.
16. Identify types of geographic coordinates found on a USGS quadrangle map.
17. Select true statements concerning the BLM Land Information System (LIS).

Objective Sheet

18. Answer questions based on the U.S. Public Land Survey System. (Assignment Sheet 1)

19. Write and locate descriptions for the subdivision of a section. (Assignment Sheet 2)

20. Write a lot and block description. (Assignment Sheet 3)

21. Identify components used to develop a plat. (Assignment Sheet 4)

22. Identify geographic coordinates on a USGS quadrangle map. (Assignment Sheet 5)

23. Scale on a UTM grid. (Assignment Sheet 6)

Information Sheet

Objective 1

Terms and definitions

a. **Azimuth**—A horizontal direction measured in degrees from 0 to 360, usually measured from the north

b. **Base line**—A principal parallel line that runs straight east and west that is used in establishing the public land survey system; is run astronomically by surveyors

c. **Bearing**—The direction of a line with respect to the quadrants of a compass starting from north or south

d. **Benchmark**—A relatively permanent material bearing a mark of elevation whose elevation is above or below the adopted datum

e. **Bounds**—Monuments which define the boundary or limit of property

Note: In the early definition, bounds were anything to describe the limits of the land (trees, ridge lines, barns).

f. **Central meridian**—The line of longitude at the center of a projection

g. **Chain**—A measurement tool composed of links, originally 66 feet in length

h. **Coordinates**—Linear and (or) angular quantities that designate the position of a point in relation to a given reference frame

i. **Coordinates, origin of**—Point in a system of coordinates which serves a zero point in computing the system's elements or in prescribing its use

j. **Course**—In surveying, the direction of a line with reference to a meridian

k. **Datum**—Any numerical or geometrical quantity or set of such quantities which may serve as a reference or base for other quantities. In ordinary survey usage is a defined reference for survey measurements

l. **Deed**—Legal document which specifies the ownership of the land

m. **Easement**—An interest or right in land owned by another that entitles its holder to a specific limited use

n. **Elevation**—Vertical distance from a datum (generally mean sea level) to a point or object on the earth's surface

o. **Geodetic survey**—A survey of large areas of land in which corrections are made for the curvature of the earth's surface; the process of triangulation is used

p. **Land survey**—A survey that locates property corners and boundary lines; usually closed with a traverse

q. **Latitude**—Arc distance measured in degrees north and south of the equator

r. **Legal description**—A written statement recognized by law as a definite location of a tract of land by reference to a survey, recorded map, or adjoining property

s. **Longitude**—Arc distance measured in degrees east and west from the prime meridian

t. **Lot and block**—A method that describes land by referring to a recorded plat, lot numbers, county, and state

u. **Magnetic meridian**—The direction a free magnet responds to the earth's magnetic pull

v. **Meridian**—Line of longitude that runs straight north and south; is run astronomically by surveyors

w. **Metes**—To measure or to assign by measure, as in the measurement of property lines expressed in units of feet, yards, or rods

x. **Monument**—Permanent object that marks established points

- Natural: Created by nature

  Examples: Trees, rivers

- Artificial: Created by human beings

  Examples: Wooden stake, stone or other permanent marker properly located and witnessed

y. **Plat**—A map of a piece of land recorded in the county clerk and recorder's office

z. **Plot plan**—A plan showing where a building is to be placed with proposed utility locations; not recorded with the county

aa. **Point of beginning**—Established corner from which measurements are started

bb. **Prime meridian**—The meridian of longitude 0°; the meridian of Greenwich, England cc. **Principal meridian**—A meridian established as a basis for establishing a reference line for the organization of the public land survey system

dd. **Public domain (lands)**—Any or all of those areas of land ceded to the federal government by the original states and to such other lands as were later acquired by treaty, purchase, or cession and are disposed of only under the authority of Congress

ee. **Subdivision (real estate)**—An unimproved tract of land surveyed and divided into lots for purposes of sale

ff. **Subdivision (USPLS)**—The subdivision of a township such as into sections, township and range numbers and the description of the principal meridian to which referred

Note: The subdivision of a section into half section, quarter section, quarter-quarter section, or sixteenth section or lotting is known as the ALIQUOT portion of a section.

gg. **Subdivision survey**—A type of land survey in which the legal boundaries of an area are located and the area is divided into parcels of lots, streets, right-of-ways, etc.

Note: By law, subdivisions have to be surveyed.

hh. **Traverse**—In surveying a sequence of lengths and directions of lines between points on the earth, obtained by field measurements and used to determine the positions of points through use of trigonometric computation

ii. **Triangulation**—A method of surveying in which the stations are points on the ground at the vertices of a chain or network of triangles

jj. **Triangulation station**—A marked and/or described point whose position has been determined by triangulation

Objective 2

Concepts that are fundamental to map projections and reference systems

a. Map projection—A system to portray all or part of the round earth on a plane surface

Note: Some systems are projected geometrically; others mathematically.

b. Graticule—A network of lines or ticks representing the geographic parallels and meridians for the map projection

c. Grid—Two sets of parallel lines intersecting at right angles, forming a rectangular Cartesian coordinate system superimposed on a map projection

Note: Sometimes the term "grid" is used loosely to mean the projection system itself rather than the rectangular system superimposed on the projection.

Objective 3

Factors in the selection of a map projection

Note: The basic problem of map projection is to reduce to the map plane the terrestrial properties of true areas, shapes, distances, and directions and the condition that the earth's parallels intersect the meridians at right angles. It is impossible to preserve all the properties simultaneously, so it is necessary to select a projection preserving the property most desired.

a. Areas—Any area on the earth's surface should be represented by the same area at the scale of the map

  - Same size area on the map will represent the same size area on the ground
  - This projection is known as "equal area or equivalent"

b. Distances—The distance between two points on the earth should be correctly represented on the map

  - Lines such as the equator or meridians are used
  - This projection is termed "equidistant"

c. Directions—The azimuths (horizontal direction clockwise from the meridian plane) from point to point on the earth should be correct on the map

  - This factor is usually limited to a center point of the projection
  - The graticule about the point must be symmetrical
  - This projection is termed "azimuthal" or"zenithal"

d. Shapes—Any shape on the earth, such as a body of water, should be represented truly on the map

  - This requires that parallels and meridians meet at right angles
  - The scale will be constant in any azimuth
  - The projection is termed "conformal"

Objective 4

Projections used by the U.S. Geological Survey (USGS)

a. Albers equal area projection with standard parallels at 29.5° and 45.5° (U.S. base map at 1:2,500,000 scale)

b. Lambert conformal conic projection with standard parallels at 33° and 45° (State base maps at 1:500,000 scale)

c. Universal Transverse Mercator Projection (UTM) (1:250,000 scale series, 1:100,000 scale series, and Alaska 1:63,360 scale series)

d. Lambert and Transverse Mercator—The state coordinate systems (15′ and 7.5 minute series)

Note: There are many ways in which map projections can be classified: by manner of development such as conic or cylindrical; by their properties such as conformal, azimuthal, or equal area; or by their inventors' names such as Mercator or Lambert.

Objective 5

Methods of legal land descriptions

a. U.S. public land survey system—A system inaugurated by the Continental Congress on May 20, 1785, for the survey of the public lands of the United States. Its distinguishing characteristic is that in the main, and in all cases where practical, its units are rectangular in form

b. Lot and block description—A method of describing land by referring to a recorded plat, the lot number, the county, and state

c. Metes and bounds survey—A survey of an irregularly-shaped tract of land, not conforming to the rectangular system of survey

d. State plane coordinate systems—The systems established by the U.S. Coast and Geodetic Survey, one for each state in the union, used for defining positions of geodetic stations in terms of plane-rectangular (X and Y) coordinates

e. Coordinate system (user defined)—A particular kind of reference frame or system, such as plane rectangular coordinates or spherical coordinates, that uses linear or angular quantities to designate the position of points within that particular reference frame or system

Objective 6

Facts to understand about coordinate systems

a. Coordinate systems are used with survey equipment and computer aided mapping for location of points.

b. Coordinates are numbers that represent distances north or east of a reference point (northings and eastings).

c. Coordinate systems employ trigonometric relationships between points to determine distances and bearings exactly.

d. Coordinate systems facilitate the location and plotting of property corners and other survey points with accuracy and precision.

e. Coordinate reference points can be real or imagined.

Note: Refer to Unit 6, "Interpretation of Surveyor's Notations," for more detailed information on working with coordinate systems.

Objective 7

United States public land survey (USPLS) system

a. Thirty-seven *initial points* have been established which serve as the starting points for subdividing the public lands.

b. *Principal meridians* and *base lines* pass through initial points and make up the framework upon which this system is built.

Note: Refer to Student Supplement 1—Principal Meridians and Base Lines.

- There are 35 principal meridians.
  - A north-south line is designated the principal meridian for a particular state or area.
  - The principal meridian is marked and monumented, and is fixed by a longitudinal reading (so many degrees, minutes, and seconds west of the Greenwich Meridian).
  - Some principal meridians are numbered, some are named.

    Examples: 5th principal meridian, Louisiana meridian, Black Hills meridian
- There are 32 base lines.
  - These are east-west lines run at right angles (90°) to the principal meridian.
  - Location of each (latitude) is fixed astronomically (so many degrees north of the equatorial line).

c. The first subdivision of public land is into quadrangles (tracts) which are approximately 24-mile squares.

Note: Refer to Student Supplement 2—U.S. Public Land Survey System.

d. To compensate for the convergence of the lines due to curvature of the earth,

- *Correction lines* (also called *standard parallels*) are run parallel to base lines.
- *Correction lines* serve as a new base line every 24 miles.
- *Guide meridians* are run parallel to principal meridians.

e. Townships

- The quadrangles (24-mile squares) are divided into small tracts of land called townships.
- *Township lines* are east-west lines at six-mile intervals parallel to the base line.

- *Range lines* are north-south lines at six-mile intervals parallel to the principal meridian.

- In order to locate a township, two numbers are assigned: a township number and a range number.

  Example: T2S, R4E, T6N, R2W

f. Sections

- A Congressional act in 1796 directed each township to be subdivided into 36 sections.

- Each section measures approximately one square mile (640 acres).

- Each section corner is to be monumented.

- The sections in each township are numbered consecutively from 1 to 36 beginning with #1 in the northeast corner of the township and #36 in the southeast corner.

  Figure 1

N

	6	5	4	3	2	1	
	7	8	9	10	11	12	
W	18	17	16	15	14	13	E
	19	20	21	22	23	24	
	30	29	28	27	26	25	
	31	32	33	34	35	36	

S

g. Fractional sections

- Are all sections bordering on the north and west sides of the township

  Note: Each township does not form a perfect square due to the convergence of meridians and other causes.

- Are expected in counties bordering oceans, lakes, and streams

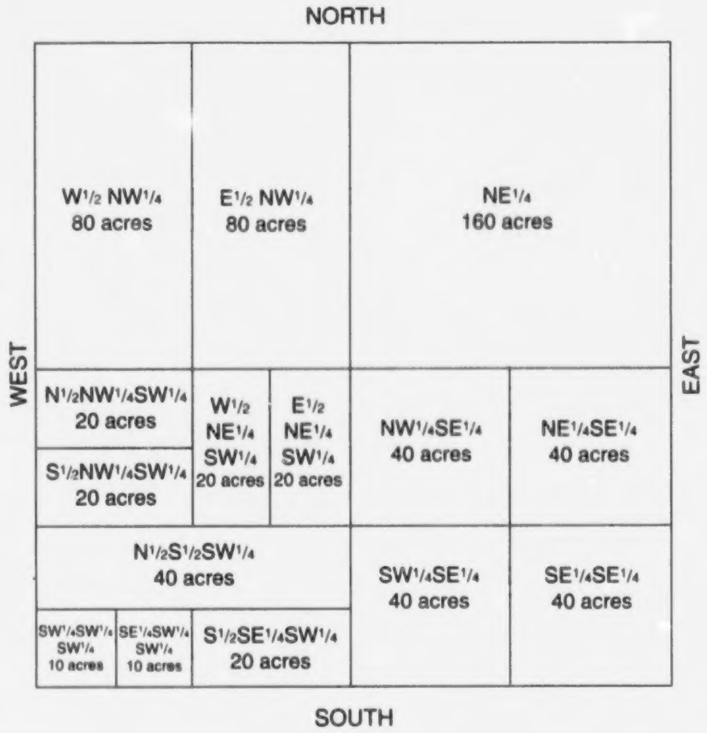
- Should be divided into equal fractional parts (if possible) with the remaining portions divided into government lots

  Example: "Government Lot 1 in the N.W. quarter of fractional section______, township______, north______, range______east

Objective 8

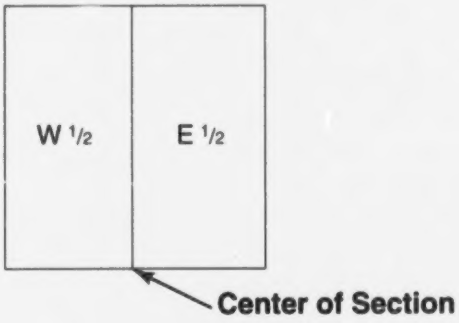
Subdivision of a section

Figure 2


NORTH
W½ NW¼
80 acres
E½ NW¼
80 acres
NE¼
160 acres
WEST
EAST
N½NW¼SW¼
20 acres
S½NW¼SW¼
20 acres
W½
NE¼
SW¼
20 acres
E½
NE¼
SW¼
20 acres
NW¼SE¼
40 acres
NE¼SE¼
40 acres
N½S½SW¼
40 acres
SW¼SE¼
40 acres
SE¼SE¼
40 acres
SW¼SW¼
SW¼
10 acres
SE¼SW¼
SW¼
10 acres
S½SE¼SW¼
20 acres
SOUTH

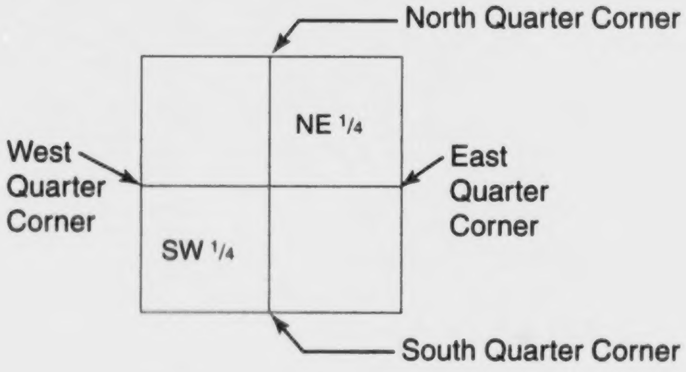
a. In 1800 Congress directed that a section could be subdivided in east and west halves (320 acres each).

Figure 3


W ½
E ½
Center of Section

b. In 1805 Congress directed further subdivision into quarter sections and the monumenting of all quarter section corners.

Figure 4


North Quarter Corner
NE 1/4
West Quarter Corner
East Quarter Corner
SW 1/4
South Quarter Corner

c. At later dates Congress directed further subdivision of the section. The quarter-quarter section of 40 acres is the smallest statutory division of regular sections.

Figure 5

			NE 1/4 NE 1/4
		SW 1/4 NE 1/4	

d. Legal descriptions of land which follow the regular subdivision of a regular section must include the section, township, and range.

e. A helpful tip in reading a legal description of a section to locate a tract of land is to read it backwards.

Example Written:	N 1/2, NW 1/4, SW 1/4, SEC 6, T 55 N, R 69 W
Reads:	R 69 W, T 55 N, SECT 6, SW 1/4, NW 1/4, N 1/2

f. A complete description always begins with the smallest division and progresses to the largest.

Objective 9

Lot and block descriptions

Note: Under the public land survey system, 40 acres is the smallest subdivision of land. To further split up land into smaller parcels or lots is called the subdivision of land (subdivision plat). This utilizes lot and block descriptions of land. Refer to Student Supplement 3—Lot and Block Description.

a. Subdivision plat contains

- All boundary lines
- Controlling monuments which become the basis of the bearings
- Lines dividing into blocks, lots, and streets
- Numbering of lots and blocks
- Dimensions of each lot

b. Exact boundaries of the subdivision may be described by the public land sectional system or metes and bounds.

c. Lot and blocks describe small units of property in a subdivision.

d. A legal lot and block must be filed with the county as part of a plat.

e. Each block is numbered consecutively.

f. Each lot carries a number shown in consecutive order within the block.

g. A plat is captioned with the legal description.

Example: Typical lot and block description: Lot 9, Block 40, Boulder subdivision, City of Louisville, Boulder County, State of Colorado

h. Advantage of lot and block description is it shows all lots in relationship to other parcels of land.

i. Recordation of subdivisions

- Deed of conveyance shows only the lot and block numbers, the subdivision name and section, and township and range information
- Government survey shows the entire subdivision

Objective 10

Metes and bounds descriptions

Note: Refer to Student Supplement 4—Typical Metes and Bounds Description.

a. Oldest known manner of describing land

Note: Before a grid system was established to describe land, early settlers described their property by metes and bounds. Early settlers described their property as extending from one landmark to another. The original property boundaries are still valid, but have been retraced using current survey methods.

b. Method employed for demarcation of tracts of land in the original 13 states

c. A method to describe irregularly shaped parcels of land that are not part of a recorded plat

d. Bearings and distances serve to traverse the property in a metes and bounds description

e. Description must begin at some known point that can be readily identified.

f. Begins at some point in the boundary of the tract and then recites the courses (directions) and distances from point to point entirely around the tract

g. All bounds are listed in rational order and referenced to a chart by bearing, distance, and monuments.

h. The description must close—The courses and distances of a description must come back to the place of beginning.

i. A plat is drawn from a metes and bounds description.

Note: A complete description of real property may include all three types of descriptions in combination—sectional system, metes and bounds, and/or lot and block description.

Objective 11

Components used to develop a plat

a. City name

b. County name

c. State name

d. Lot or parcel number, letter, or name

e. Name or number of the map (file reference number if officially filed and page number)

f. Point of beginning

g. Bearings/azimuth and distances

h. Monuments

i. If part of public lands,
  - Section number
  - Township number
  - Range number
  - Meridian

j. If part of private land grant, (such as Spanish land grant) reference to its map or book and page number

Information Sheet

Objective 12

State plane coordinates

Note: Refer to Student Supplement 6—State Plane Coordinate Grid Systems.

a. Was established in 1933 by the U.S. Coast and Geodetic Survey

b. Uses a rectangular grid designed to fit the curved shape of the earth to a plane surface with as little distortion as possible

c. Is used for defining positions of geodetic stations in terms of plane rectangular (X and Y) coordinates

d. All states have established by law a state plane coordinate system in either the Lambert projection or the transverse Mercator projection with one or more zones.

e. Lambert and Mercator grid systems each select one true meridian (known as the central meridian).

f. All north-south lines of the grids are drawn parallel to the central meridian.

g. The Lambert projection grid assigns an X value at the central meridian (Y axis) of 2,000,000 ft and a Y value at the X axis of "0" ft.

h. The Mercator projection grid assigns an X value to the central meridian (Y axis) of 500,000 ft and a Y value to the X axis of "0" ft.

i. The transverse Mercator projection was limited to 158 miles (approx.) in the east-west width to minimize distortion.

j. The Lambert projection was limited to 158 miles (approx.) in the north-south direction to minimize distortion.

k. Coordinates are based on sea level.

Note: If the local survey is tied into coordinate grid points and is not at sea level, it is necessary to convert the geodetic lengths to ground level distances.

l. Is used extensively for photogrammetric plotting and electronic surveying

m. Scale error varies from zero up to about one part in 10,000.

n. Use of the state plane coordinate system depends on the availability of a sufficient number of geodetic control monuments to permit the determination of the grid position of points in the survey by plane surveying.

Note: Consult your state codes to determine the extent to which coordinates have been established, the form of designation assigned to them, and their legal connotation.

Objective 13

Legal aspects of land acquisition

a. Adverse possession (also known as Squatter's Rights)—These basic elements must be present for a period of 10-20 years before adverse rights change to legal title.

- Possession is against wishes of owner and without consent.
- Possession is open; claimant's intentions are obvious.
- Actual improvements are present.

  Examples: Fences, construction, farming
- Possession is exclusive, continuous, and hostile to the rightful owner.

b. Eminent domain—The right of a public authority to take property for public use; requisites for eminent domain include

- A clear statement of necessity is made.
- The acquisition is in the public interest.
- No substitute property will do.
- Reimbursement will be at fair market value to the owner.

c. Acquiescence of possession

- Two adjoining property owners agree to a common boundary that does not follow the original surveyed line.
- Elements for modification of title include
  - Area in question must be used exclusively and openly by respective property owner.
  - Period of use must elapse 20 years.
  - There must be a physical demarcation such as a fence between the two properties.
  - There must be no disagreement between the two parties as to appropriateness of the line during the statutory period.

d. Riparian rights—Refers to those rights of a property owner of land that borders on a water body

- The rights include the use of the shore and ownership of land under the water surface and therefore use of the water.
- Ownership may extend only to the high water mark or to the center of a stream or river.
- Boundaries are both irregular and subject to change.
- Shoreline road allowances: certain survey systems incorporate a publicly owned strip (usually 1 chain wide) parallel with the shoreline or high water mark.

Information Sheet

Objective 14

Types of boundary classifications (based on original source documents)

Note: Original boundary surveys executed by the appropriate organization provide the definitive evidence for setting boundary questions, so the source documents, not the survey's topographic maps, have primary legal significance with respect to land ownership or jurisdictional limits.

a. International boundaries of U.S.—Established through treaties made by the nations concerned

b. State boundaries—Defined by Congress and can be changed only by agreement of legislature of the concerned state and consent of Congress

c. Civil boundaries within a state—Boundaries are usually fixed by state legislative action or local counties

d. Incorporated areas—Boundaries are kept by local and county offices (cities, towns, villages, and special purpose tracts of land)

e. Corporate boundaries—Described in the articles of incorporation

f. Land grant and public land survey lines in accordance with principles given in the section on public land subdivision monitored by the Bureau of Land Management (formerly the General Land Office)

Objective 15

Boundary precedence

a. If boundaries of two or more civil units of different rank coincide, the symbol for the higher ranking unit boundary is shown on the map.

b. The following are boundary units ranked in order:

- National
- State, commonwealth, and territory
- County (parish, borough, or municipality)
- County subdivisions, civil townships, or towns
- Other incorporated places that do not have the status of counties

Objective 16

Types of geographic coordinates found on a USGS quadrangle map

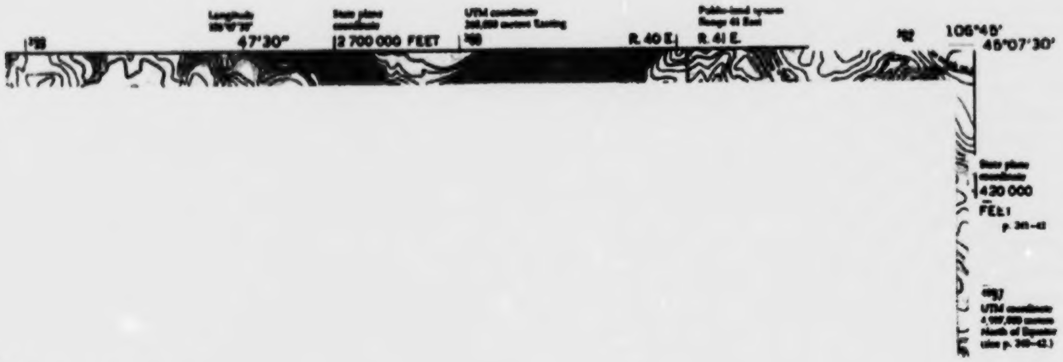
a. Longitude and latitude

b. State plane coordinates

c. UTM (Universal Transverse Mercator) grid system

d. Public land system (township and range)

Figure 6



U.S. Geological Survey

Objective 17

BLM Land Information System

a. The Bureau of Land Management (BLM) is responsible for managing vast portions of public land acreage. To assist in this land management, the BLM is implementing a multipurpose land information system.

b. Land information system (LIS)

- Automated land and mineral record system (ALMRS)—This program catalogs data related to land parcel descriptions, including land status, mining claims, oil and gas leases, and other records
- Automated resource data (ARD)—Includes various natural resource and wildlife information

c. The objectives of the LIS are to

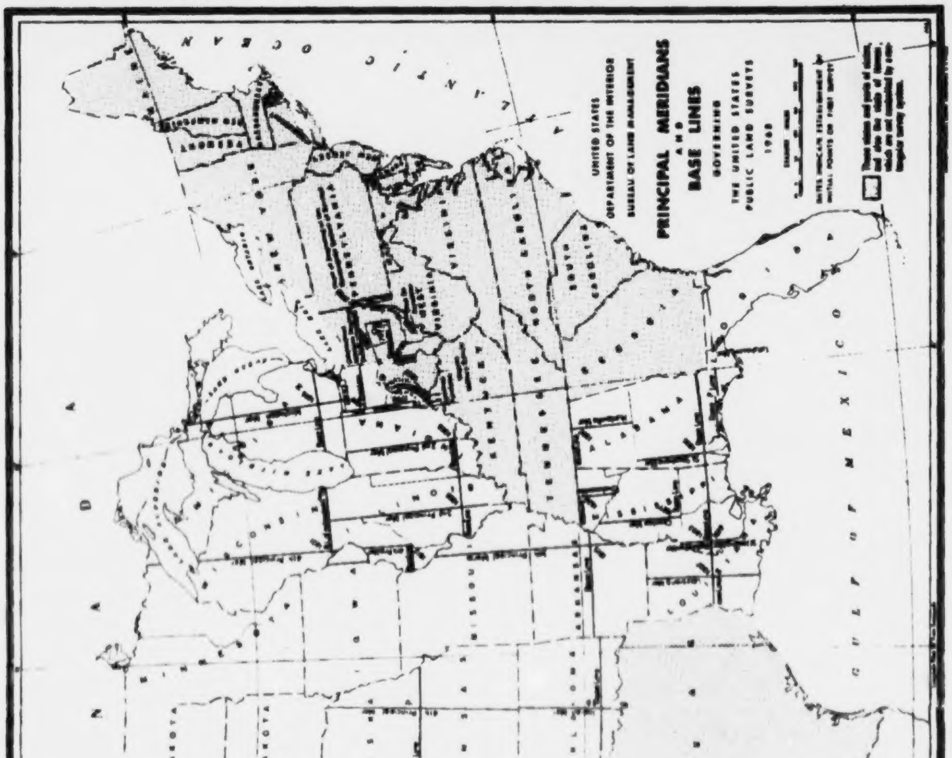
- Streamline responses to land and mineral inquiries
- Facilitate processing applications and permits
- Simplify access to all records
- Improve physical security of records and protect proprietary information
- Ensure accurate and consistent data
- Aid in planning and monitoring of programs
- Reduce cost of land management

d. To support the LIS, the Bureau of Land Management is creating a new geographic data base.

- This geographic data base (GCDB) is a digital layer of information on the public land survey system (PLSS).
- GCDB will provide positional components necessary for correlating all other information in the LIS.
- GCDB will include:
  - Geographic coordinates of all PLSS corners
  - Estimates of their reliability
  - Identification of the surveyors who set the corners
  - Types of corners set and dates placed
  - Records of resurveyed land
  - Full record of ownership of each parcel
  - Ownership of abutting parcels

608

Student Supplement 1—Principal Meridians and Base Lines


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
PRINCIPAL MERIDIANS
AND
BASE LINES
GOVERNING
THE UNITED STATES
PUBLIC LAND SURVEYS
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
CANADA
PACIFIC OCEAN
ALASKA

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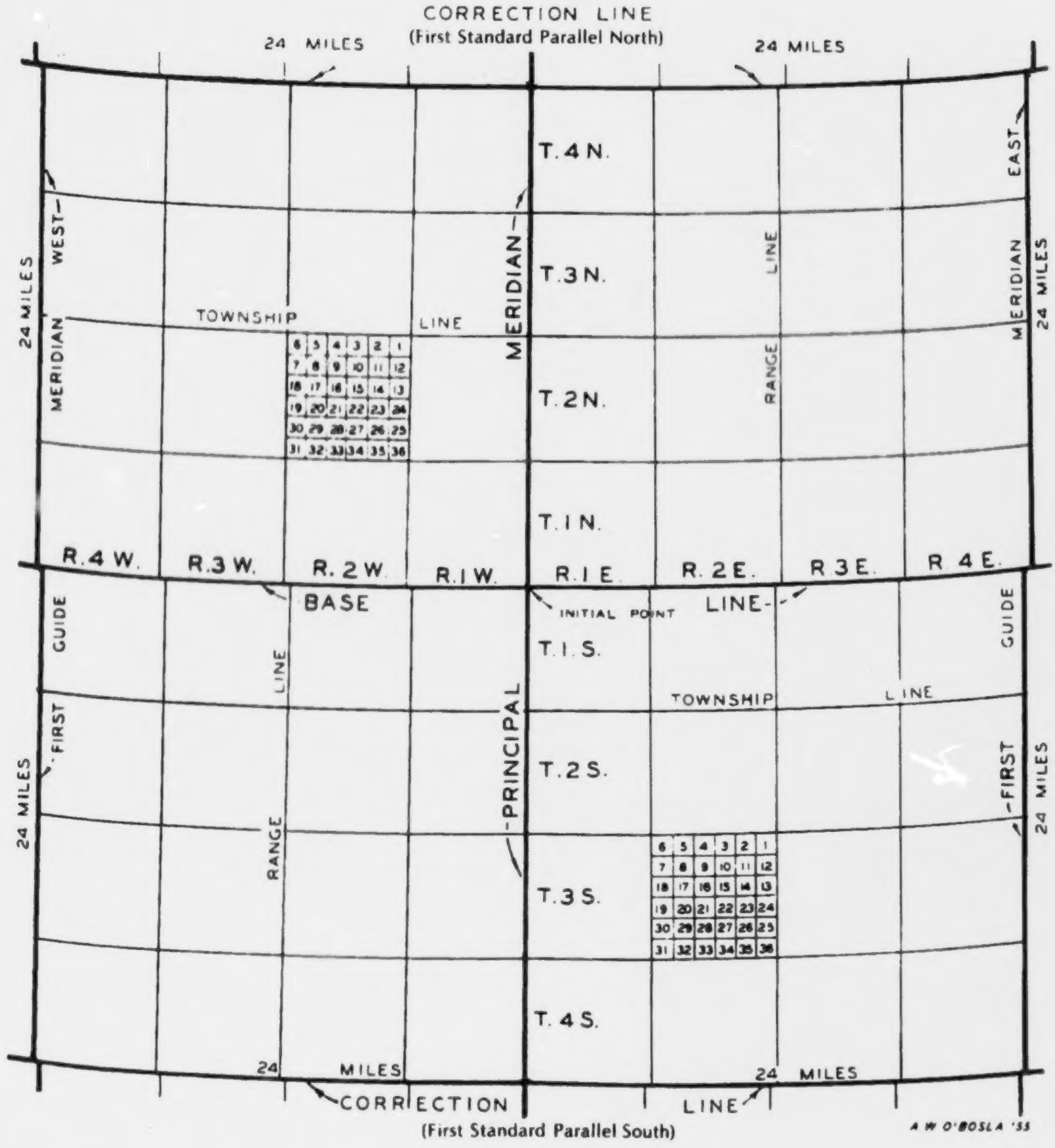
Student Supplement 2—U.S. Public Land Survey System


CORRECTION LINE
(First Standard Parallel North)
24 MILES
24 MILES
24 MILES
WEST—MERIDIAN
EAST—MERIDIAN
MERIDIAN
PRINCIPAL
T. 4 N.
T. 3 N.
T. 2 N.
T. 1 N.
T. 1 S.
T. 2 S.
T. 3 S.
T. 4 S.
TOWNSHIP LINE
RANGE LINE
R. 4 W.
R. 3 W.
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R 3 E.
R 4 E.
BASE LINE
INITIAL POINT
FIRST GUIDE
24 MILES
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36
CORRECTION LINE
(First Standard Parallel South)
A W O'BOSLA '55

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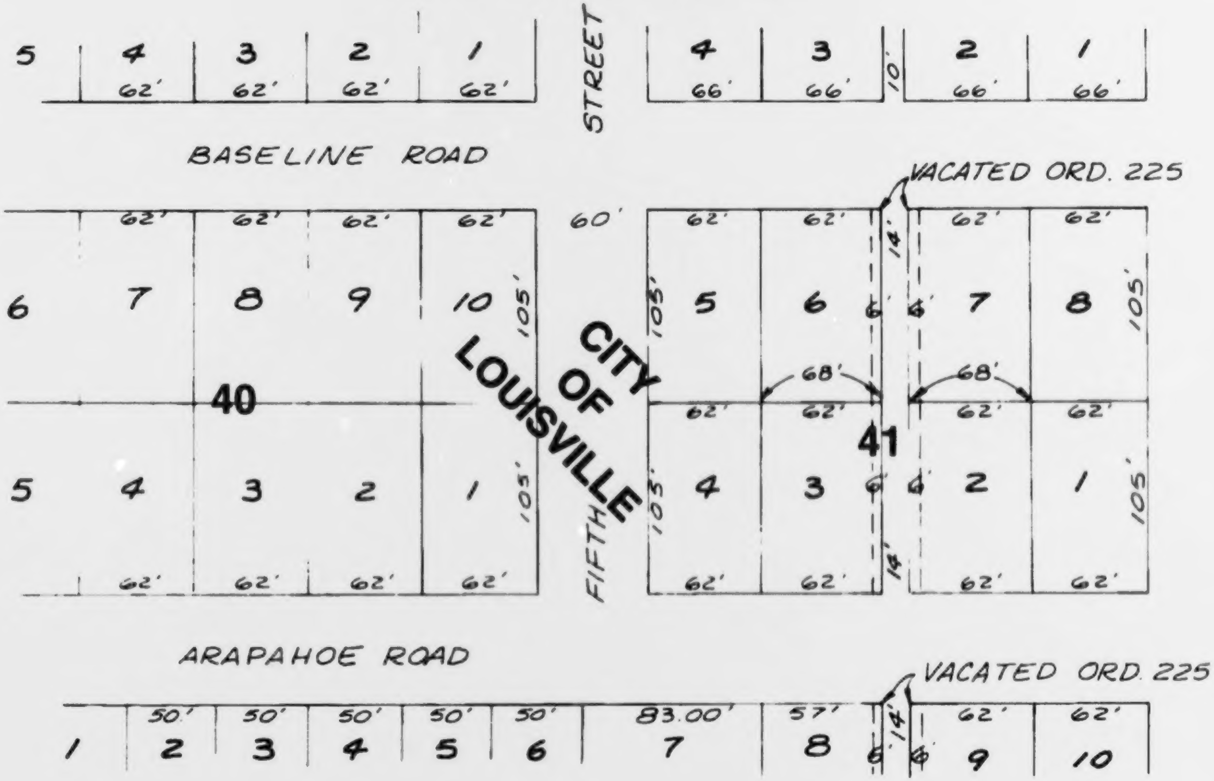
610

LOT 8, BLOCK 40, BOULDER SUBDIVISION, CITY OF LOUISVILLE, BOULDER COUNTY STATE OF COLORADO


BASELINE ROAD
STREET
FIFTH
ARAPAHOE ROAD
VACATED ORD. 225
VACATED ORD. 225
CITY OF LOUISVILLE
40
41
60'
62'
66'
10'
14'
105'
103'
68'
50'
83.00'
57'
6'

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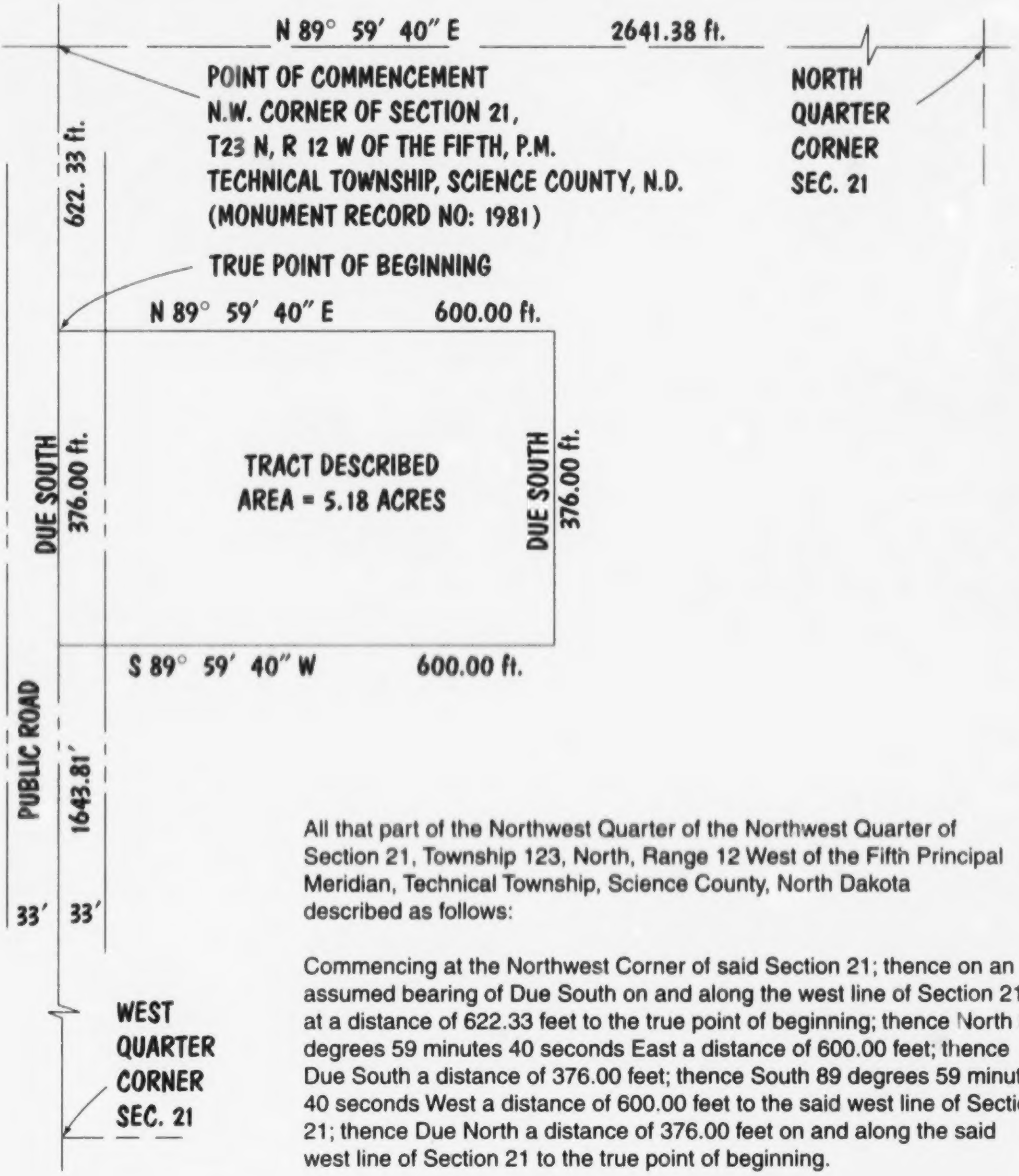
611

612

Student Supplement 4—Typical Metes and Bounds Description

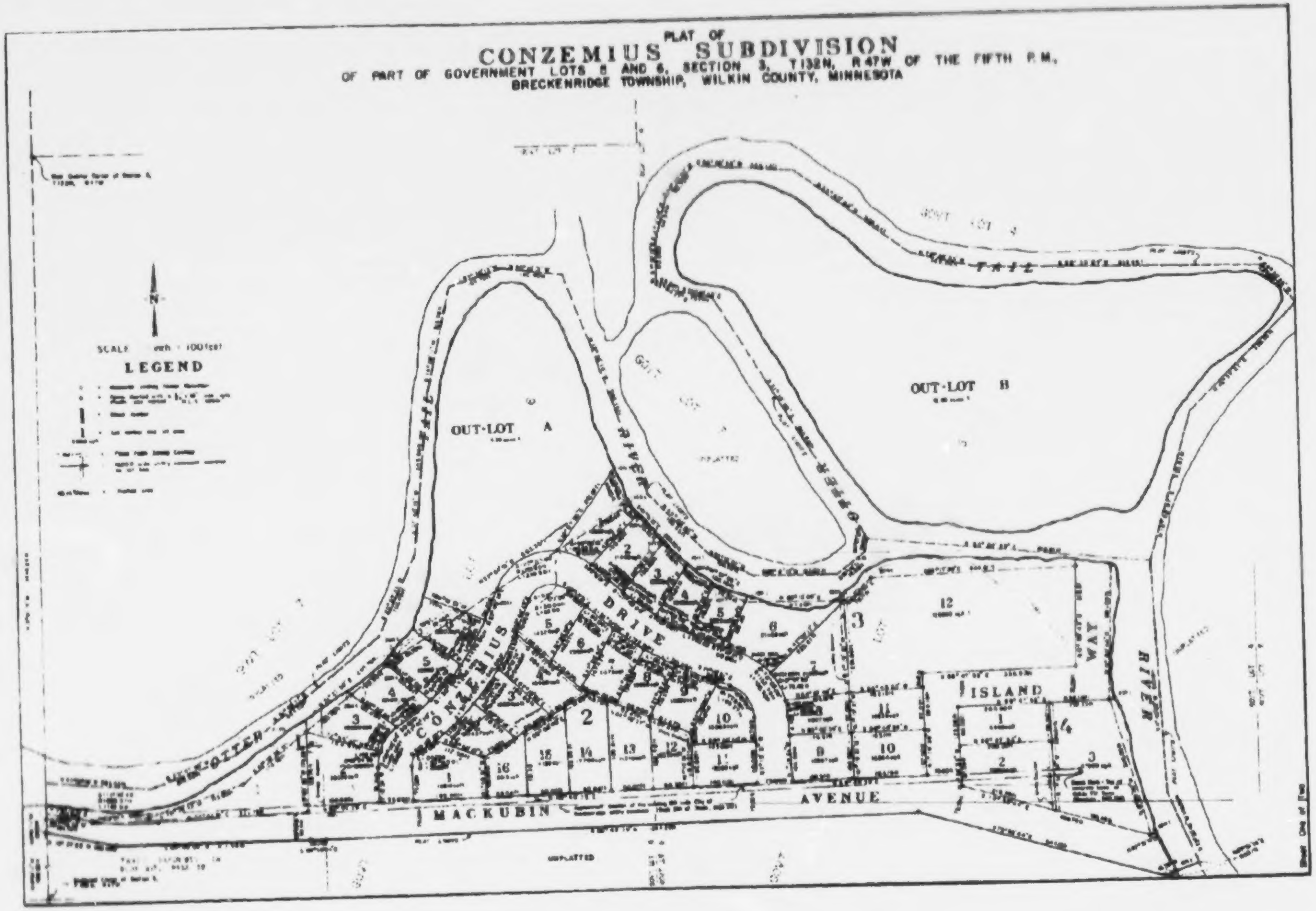

N 89° 59′ 40″ E
2641.38 ft.
POINT OF COMMENCEMENT
N.W. CORNER OF SECTION 21,
T23 N, R 12 W OF THE FIFTH, P.M.
TECHNICAL TOWNSHIP, SCIENCE COUNTY, N.D.
(MONUMENT RECORD NO: 1981)
NORTH
QUARTER
CORNER
SEC. 21
622. 33 ft.
TRUE POINT OF BEGINNING
N 89° 59′ 40″ E
600.00 ft.
DUE SOUTH
376.00 ft.
TRACT DESCRIBED
AREA = 5.18 ACRES
DUE SOUTH
376.00 ft.
S 89° 59′ 40″ W
600.00 ft.
PUBLIC ROAD
1643.81′
33′
33′
WEST
QUARTER
CORNER
SEC. 21

All that part of the Northwest Quarter of the Northwest Quarter of Section 21, Township 123, North, Range 12 West of the Fifth Principal Meridian, Technical Township, Science County, North Dakota described as follows:

Commencing at the Northwest Corner of said Section 21; thence on an assumed bearing of Due South on and along the west line of Section 21 at a distance of 622.33 feet to the true point of beginning; thence North 89 degrees 59 minutes 40 seconds East a distance of 600.00 feet; thence Due South a distance of 376.00 feet; thence South 89 degrees 59 minutes 40 seconds West a distance of 600.00 feet to the said west line of Section 21; thence Due North a distance of 376.00 feet on and along the said west line of Section 21 to the true point of beginning.

The above described tract contains 5.18 acres more or less and is subject to an existing public road over and across its most westerly 33.00 feet.

Student Supplement 5—Sample Plat


PLAT OF
CONZEMIUS SUBDIVISION
OF PART OF GOVERNMENT LOTS 5 AND 6, SECTION 3, T132N, R47W OF THE FIFTH P.M.,
BRECKENRIDGE TOWNSHIP, WILKIN COUNTY, MINNESOTA
N
SCALE
LEGEND
OUT-LOT A
OUT-LOT B
CONZEMIUS
DRIVE
MACKUBIN
AVENUE
ISLAND
WAY
RIVER
UNPLATTED
GOVT. LOT

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Student Supplement 6—State Plane Coordinate Grid Systems

The mapping grid systems used in the United States vary from state to state, and in some cases, from state zone to state zone. The following is a listing of the states, their zones, and the grid system used per zone. It will be observed that there are two grid systems used in the United States: the Lambert conformal projection, and the transverse Mercator projection.

State and Zone	Mapping Grid System
Alabama	
eastern	transverse Mercator projection
western	transverse Mercator projection
Alaska	
zone 1	oblique transverse Mercator projection
zones 2-9	transverse Mercator projection
zone 10	Lambert conformal projection
Arizona	
eastern	transverse Mercator projection
central	transverse Mercator projection
western	transverse Mercator projection
Arkansas	
northern	Lambert conformal projection
southern	Lambert conformal projection
California	
zones 1-7	Lambert conformal projection
Colorado	
northern	Lambert conformal projection
central	Lambert conformal projection
southern	Lambert conformal projection
Connecticut	Lambert conformal projection
Delaware	transverse Mercator projection
Florida	
eastern	transverse Mercator projection
western	transverse Mercator projection
northern	Lambert conformal projection
Georgia	
eastern	transverse Mercator projection
western	transverse Mercator projection
Hawaii	
zones 1-5	transverse Mercator projection
Idaho	
eastern	transverse Mercator projection
central	transverse Mercator projection
western	transverse Mercator projection
Illinois	
eastern	transverse Mercator projection
western	transverse Mercator projection
Indiana	
eastern	transverse Mercator projection
western	transverse Mercator projection

State and Zone	Mapping Grid System
Iowa	
northern	Lambert conformal projection
southern	Lambert conformal projection
Kansas	
northern	Lambert conformal projection
southern	Lambert conformal projection
Kentucky	
northern	Lambert conformal projection
southern	Lambert conformal projection
Louisiana	
northern	Lambert conformal projection
southern	Lambert conformal projection
Maine	
eastern	transverse Mercator projection
western	transverse Mercator projection
Maryland	Lambert conformal projection
Massachusetts	
mainland	Lambert conformal projection
island	Lambert conformal projection
Michigan	
eastern	transverse Mercator projection
central	transverse Mercator projection
western	transverse Mercator projection
Minnesota	
northern	Lambert conformal projection
central	Lambert conformal projection
southern	Lambert conformal projection
Mississippi	
eastern	transverse Mercator projection
western	transverse Mercator projection
Missouri	
eastern	transverse Mercator projection
central	transverse Mercator projection
western	transverse Mercator projection
Montana	
northern	Lambert conformal projection
central	Lambert conformal projection
southern	Lambert conformal projection
Nebraska	
northern	Lambert conformal projection
southern	Lambert conformal projection

Student Supplement 6

State and Zone	Mapping Grid System
Nevada	
eastern	transverse Mercator projection
central	transverse Mercator projection
western	transverse Mercator projection
New Hampshire	transverse Mercator projection
New Jersey	transverse Mercator projection
New Mexico	
eastern	transverse Mercator projection
central	transverse Mercator projection
western	transverse Mercator projection
New York	
Long Island	Lambert conformal projection
eastern	transverse Mercator projection
central	transverse Mercator projection
western	transverse Mercator projection
North Carolina	Lambert conformal projection
North Dakota	
northern	Lambert conformal projection
southern	Lambert conformal projection
Ohio	
northern	Lambert conformal projection
southern	Lambert conformal projection
Oklahoma	
northern	Lambert conformal projection
southern	Lambert conformal projection
Oregon	
northern	Lambert conformal projection
southern	Lambert conformal projection
Pennsylvania	
northern	Lambert conformal projection
southern	Lambert conformal projection
Rhode Island	transverse Mercator projection
South Carolina	
northern	Lambert conformal projection
southern	Lambert conformal projection
South Dakota	
northern	Lambert conformal projection
southern	Lambert conformal projection
Tennessee	Lambert conformal projection
Texas	
northern	Lambert conformal projection
north-central	Lambert conformal projection
central	Lambert conformal projection
south-central	Lambert conformal projection
southern	Lambert conformal projection
Utah	
northern	Lambert conformal projection
central	Lambert conformal projection
southern	Lambert conformal projection

State and Zone	Mapping Grid System
Vermont	transverse Mercator projection
Virginia	
northern	Lambert conformal projection
southern	Lambert conformal projection
Washington	
northern	Lambert conformal projection
southern	Lambert conformal projection
West Virginia	
northern	Lambert conformal projection
southern	Lambert conformal projection
Wisconsin	
northern	Lambert conformal projection
central	Lambert conformal projection
southern	Lambert conformal projection
Wyoming	
zones 1-4	transverse Mercator projection

617

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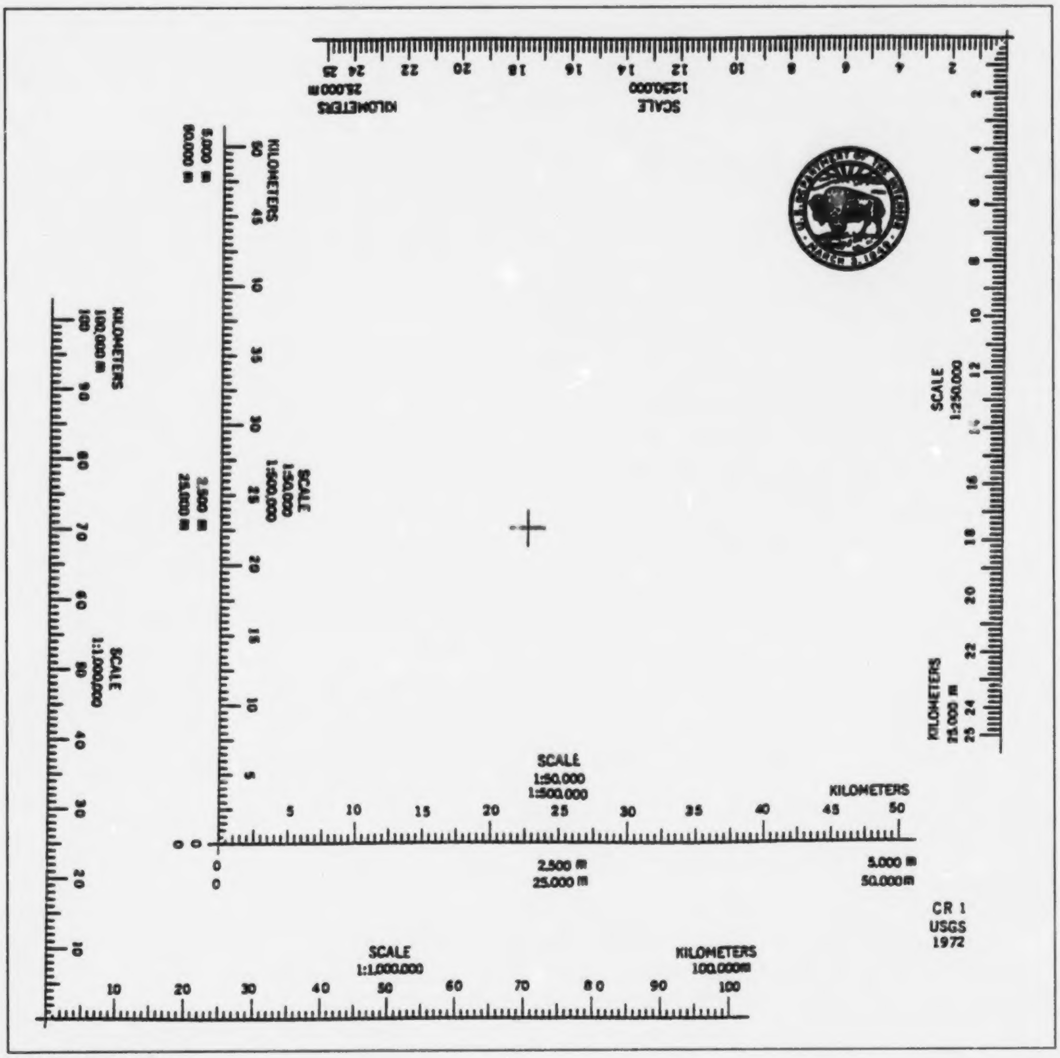
Student Supplement 7—Metric Coordinate Reader

Note: This is used by the U.S. Geological Survey for map coordinate reading with various metric scales.


SCALE
1:250,000
KILOMETERS
25,000 m
SCALE
1:50,000
1:500,000
KILOMETERS
2,500 m
25,000 m
5,000 m
50,000 m
SCALE
1:1,000,000
KILOMETERS
100,000 m
CR 1
USGS
1972

U.S. Geological Survey

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Objective 18

Assignment Sheet 1—Answer Questions Based on the U.S. Public Land Survey System

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Answers are clear and concise	______
• Answers match correctly to selected USGS quadrangle map	______

Basic Skills

Reading Critical Thinking

Directions

Using the USGS 7.5 minute quadrangle map provided by your instructor, answer the following questions.

1. The scale on this map is ____________________
2. The map series is ____________________
3. The contour interval is ____________________
4. Date of issue ____________________
5. Magnetic declination at date of issue ____________________
6. Year(s) of original survey ____________________
7. Year of revised (updated) survey ____________________
8. What would be the next map to the

   south: ______________ SE: ______________

   west: ______________ SW: ______________

   north: ______________ NW: ______________

   east: ______________ NE: ______________
9. In parts, what range(s) is covered by the map? ______________
10. In parts, what township(s) is covered by the map? ______________

11. Approximately how many square miles are covered by this map?________

12. Choose three cultural features (church, water tank, etc.), and give the legal description of each location using township and range.

a. ____

b. ____

c. ____

620

Objective 19

Assignment Sheet 2—Write and Locate Descriptions For the Subdivision Of a Section

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Answers are clear and concise	______
• Section legal description matches shaded area	______
• Acres are calculated correctly	______

Basic Skills

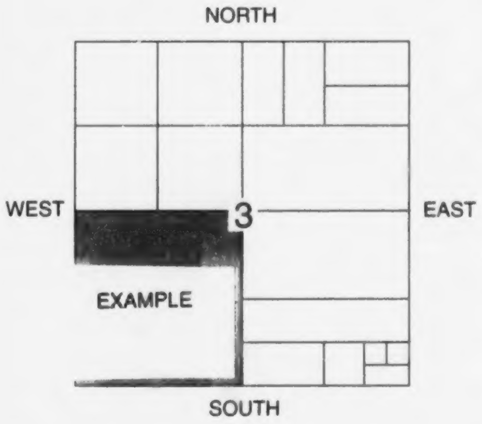
Reading

Critical Thinking

Part I Directions

Write the legal description and acreage of the shaded area of each section given. Refer to Objective 8 in the Information Sheet.

Example:

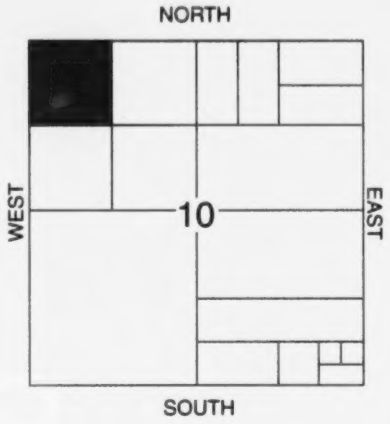


SW 1/4, Section 3

Acres: 160

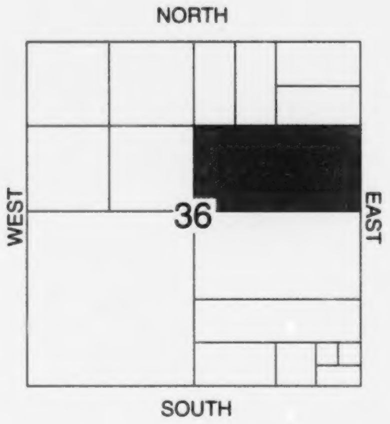
Assignment Sheet 2

a.


NORTH
WEST
10
EAST
SOUTH

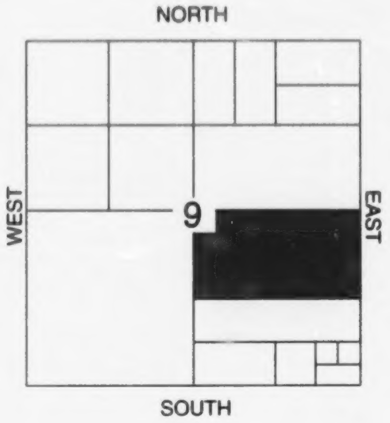
Acres: ____________

b.


NORTH
WEST
36
EAST
SOUTH

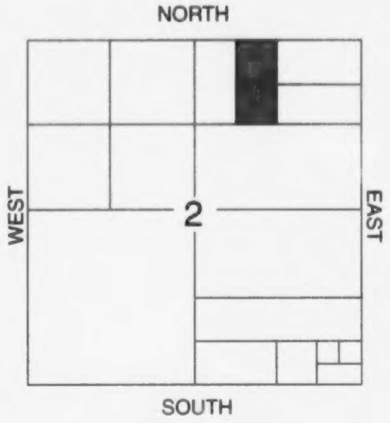
Acres: ____________

c.


NORTH
WEST
9
EAST
SOUTH

Acres: ____________

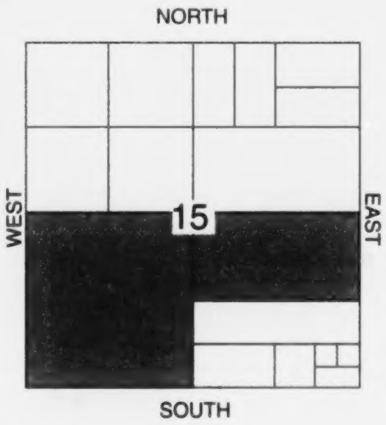
d.


NORTH
WEST
2
EAST
SOUTH

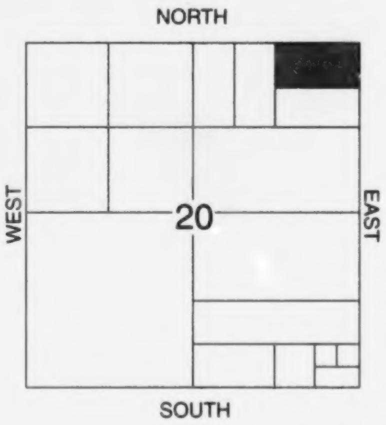
Acres: ____________

622

e.


NORTH
WEST
15
EAST
SOUTH

f.


NORTH
WEST
20
EAST
SOUTH

______________________________ ______________________________

______________________________ ______________________________

Acres: ______________________ Acres: ______________________

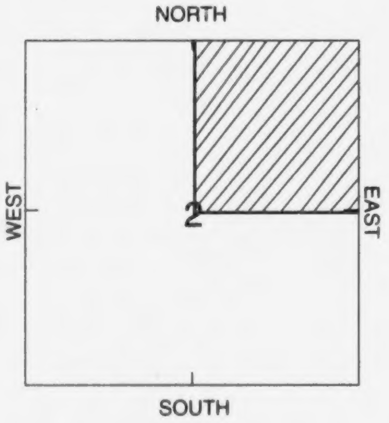
Part II Directions

The illustrations given are blocks that represent sections and legal descriptions. Using the descriptions given, do the following.

1. Label the section number in the center of section.
2. Subdivide each section according to the legal description. Shade this area in.
3. Give acreage of the shaded area in space provided.

Given Descriptions
Example: NE 1/4, SECT 2
A. SE 1/4, SE 1/4, SECT 10
B. N 1/2, NE 1/4, SECT 31
C. SW 1/4, NW 1/4, SW 1/4, SECT 7
D. SE 1/4 & S 1/2, NE 1/4, SECT 23
E. N 1/2, SECT 5
F. SE 1/4, NE 1/4, SW 1/4, SECT 16

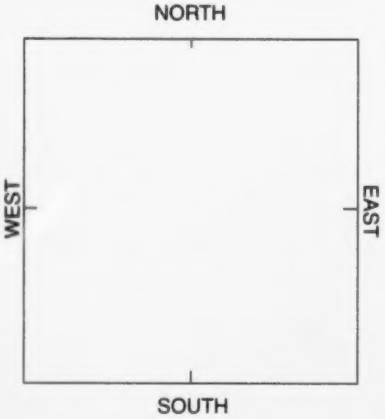
Example:


NORTH
WEST
2
EAST
SOUTH

Acres: 160

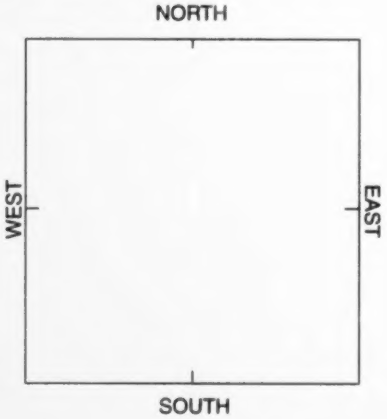
Assignment Sheet 2

a.


NORTH
WEST
EAST
SOUTH

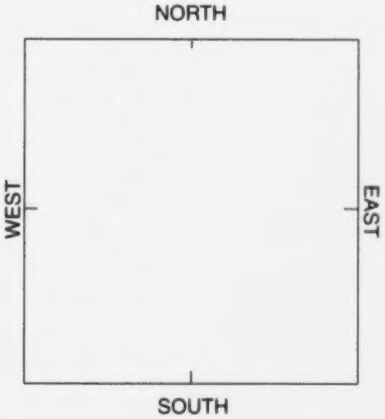
Acres: ______________________

b.


NORTH
WEST
EAST
SOUTH

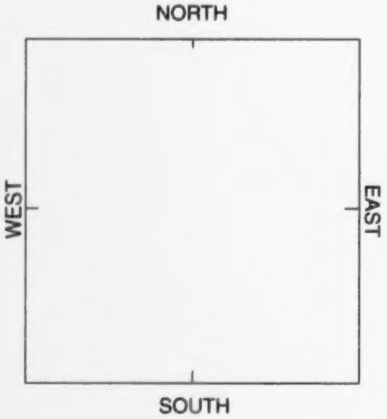
Acres: ______________________

c.


NORTH
WEST
EAST
SOUTH

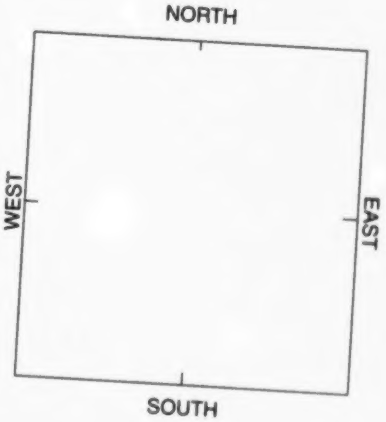
Acres: ______________________

d.

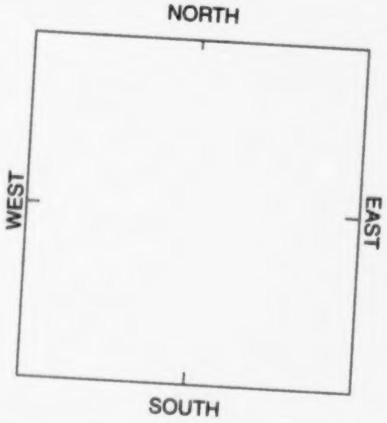

NORTH
WEST
EAST
SOUTH

Acres: ______________________

e.


NORTH
WEST
EAST
SOUTH

f.


NORTH
WEST
EAST
SOUTH

Acres: ______________________

Acres: ______________________

Objective 20

Assignment Sheet 3—Write a Lot and Block Description

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Answers are clear and concise	______
• Lot and block description match shaded area	______

Basic Skills

Reading

Critical Thinking

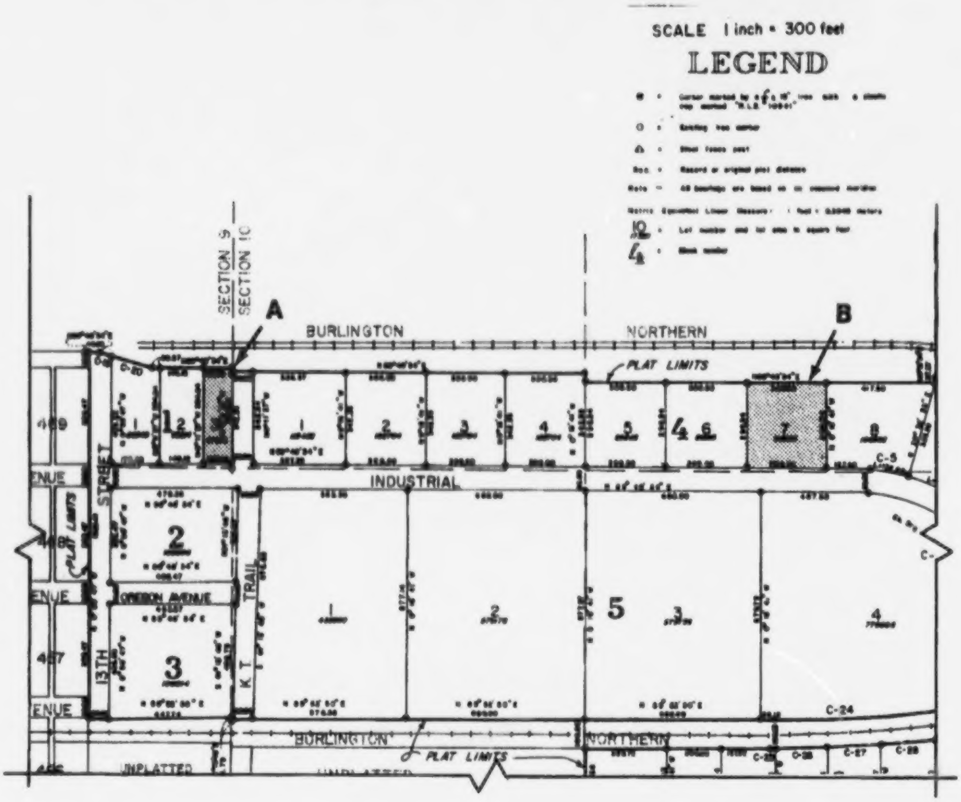
Directions

In the space provided, write a description for the two lots shaded on this partial subdivision plat.

Assignment Sheet 3

PLAT OF BRECKENRIDGE INDUSTRIAL PARK

A PART OF SECTION 9, TOWNSHIP 132 NORTH, RANGE 47 WEST WITHIN THE CITY OF BRECKENRIDGE, AND A PART OF SECTION 10, TOWNSHIP 132 NORTH, RANGE 47 WEST WITHIN BRECKENRIDGE TOWNSHIP, ALL WITHIN THE FIFTH PRINCIPAL MERIDIAN, WILKIN COUNTY, MINNESOTA


SCALE 1 inch = 300 feet
LEGEND
SECTION 9
SECTION 10
A
B
BURLINGTON
NORTHERN
PLAT LIMITS
INDUSTRIAL
STREET
13TH
TRAIL
K T
OREGON AVENUE
ENUE
PLAT LIMITS
UNPLATTED
1
2
3
4
5
6
7
8
C-5
C-24
C-27
C-28
469
468
467

a. ____

b. ____

Objective 21

Assignment Sheet 4—Identify Components Used To Develop a Plat

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Answers are clear and concise	______
• Answers correctly match map	______

Basic Skills

Reading

Critical Thinking

Directions

Using the subdivision plat provided by your instructor, answer the following questions and any additional questions provided by your instructor.

1. This subdivision is in what county? ______________________
2. This is a county in what state? ______________________
3. What is the name of the township? ______________________
4. What section is this plat in? ______________________
5. How many blocks are listed on the map? ______________________
6. How wide is the existing utility easement? ______________________
7. How wide is the drainage easement? ______________________
8. How many acres are in the platted area? ______________________
9. How many square feet are in the largest lot? ______________________
10. What is the scale of the map? ______________________
11. What number sheet is this plat? ______________________
12. How wide are the utility easements centered on the lot lines? __________
13. Give the principal meridian used to develop this plat. ______________
14. What is the quarter section of this subdivision? ______________

Objective 22

Assignment Sheet 5—Identify Geographic Coordinates on a USGS Quadrangle Map

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Answers are clear and concise	______
• Answers are evaluated to the satisfaction of the instructor	______

Basic Skills

Reading Critical Thinking

Directions

1. Locate a 7.5 minute quadrangle map of your choice.
2. Using small sticky note papers, label them with the following labels:
    - longitude
    - latitude
    - state plane coordinate
    - UTM grid system
    - public land system–township
    - public land system–range.
3. Then place each labeled sticky note next to its appropriate geographic coordinate label on the USGS 7.5 quadrangle map.
4. Have your instructor verify the correctness of your placement.

Objective 23

Assignment Sheet 6—Scale on a UTM Grid

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	**Rating**
• Answers are clear and concise	______
• Answers are measured accurately	______

Basic Skills

Reading

Critical Thinking

Note: Ask your instructor for the appropriate metric coordinate reader to use as a measuring tool on this assignment.

Directions

Following the step by step procedure given below, measure five grid distances for key points on the USGS 7.5 minute quadrangle map provided by your instructor.

Example: Measure from point A benchmark location to point B section corner.

1. To find the grid distance between point A and point B on a UTM grid, scale the eastings and northings of the positions A and B. Using the metric coordinate reader or a centimeter scale, measure from the nearest grid line to the left of and below the points.
2. Record the easting and northing of each point.
3. Solve for the grid distance by the Pythagorean equation

$$L = \sqrt{\triangle E^2 + \triangle N^2}$$

L = grid length

$$\left.\begin{matrix}\triangle E\\ \triangle N\end{matrix}\right\rangle \text{ the differences in northings and eastings between points A and B as scaled}$$

4. To find the ground distance corresponding to the grid distance, divide by the approximate scale factor of the midpoint of the two eastings.

   Note: A scale factor is the quantity by which a ground distance must be multiplied to obtain the corresponding grid distance and by which a grid distance must be divided to obtain the corresponding ground distance.

Example:

Reference System Spacing

Map scale	*State Plane Coordinate*			*UTM*		
	Tick spacing (ft on ground)	*Spacing (on map)*		*Grid spacing (m on ground)*	*Spacing (on map)*	
		inches	*mm*		*inches*	*mm*
1:20,000	10,000	6.0	152.4	1,000	1.97	50.0
1:24,000	10,000	5.0	127.0	1,000	1.64	41.6
1:25,000	10,000	4.8	122.0	1,000	1.57	40.0
1:50,000	20,000	4.8	122.0	5,000	3.94	100.0
1:62,500	20,000	3.84	97.5	5,000	3.15	80.0
1:63,360	20,000	3.78	96.0	5,000	3.10	78.7
1:100,000	50,000	6.0	152.4	10,000	3.94	100.0
1:250,000	100,000	4.8	122.0	10,000	1.57	40.0
1:500,000	200,000	4.8	122.0	50,000	3.94	100.0
1:1,000,000	500,000	6.0	152.4	100,000	3.94	100.0

Unit 6 Interpretation of Surveyor's Notations

Unit Contents

Student Components

Student Page

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Student Supplements

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2—Error Classification 6–45

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1—Plot Lines and Distances Using Several Methods 6–47
2—Convert Azimuths to Bearings and Bearings to Azimuths 6–49
3—Lay Out a Closed Traverse 6–51
4—Complete a Mathematical Closure of a Traverse 6–55
5—Reduce Four Types of Field Notes 6–61
6—Draw a Map Using Bearings, Distances, and Coordinates 6–75
7—Lay Out the Property Boundary for the
MAVCC Topographic Survey Map 6–79

Objective Sheet

Unit Objective

After completing this unit, the student should be able to reduce field notes, convert azimuth to bearing and bearing to azimuth, plot traverses by different methods, and mathematically close a traverse. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to interpretation of surveyor's notations with their definitions.
2. List the six activities that define surveying according to the International Federation of Surveyors.
3. Select true statements concerning the classifications of surveys.
4. Match types of surveys with their descriptions.
5. Define types of computer-based digital data files.
6. List government agencies that perform surveying.
7. List types of measurements used in surveying.
8. Select true statements about important characteristics in surveying measurement.
9. Define accuracy and precision.
10. Select true statements concerning accuracy ratio.
11. Match types of errors with their examples.
12. Match types of surveying equipment with their uses.
13. Select true statements concerning methods used in surveying to measure horizontal distances.
14. List methods used to determine horizontal point position.
15. Define triangulation.
16. Complete statements concerning traverses.
17. Distinguish between a bearing direction and an azimuth direction.
18. State the formulas used to convert bearings to azimuths and azimuths to bearings.

19. Select true statements concerning common methods for plotting traverses.
20. Complete statements about vertical (zenith) angles.
21. Define leveling.
22. Match terms for basic leveling with their definitions.
23. Complete statements concerning reference elevations.
24. List equipment used to level.
25. Select true statements about developing a profile from profile leveling notes.
26. Select true statements concerning stationing.
27. Complete statements concerning field notes.
28. Select true statements concerning the arrangement of field notes in the field book.
29. List advantages and disadvantages of electronically recorded notes.
30. Complete statements concerning the global positioning system (GPS).
31. Select true statements about how GPS works.
32. List the five benefits of surveying with GPS.
33. List four general applications of GPS.
34. Match types of GPS procedures with a surveying activity.
35. Plot lines and distances using several methods. (Assignment Sheet 1)
36. Convert azimuths to bearings and bearings to azimuths. (Assignment Sheet 2)
37. Lay out a closed traverse. (Assignment Sheet 3)
38. Complete a mathematical closure of a traverse. (Assignment Sheet 4)
39. Reduce four types of field notes. (Assignment Sheet 5)
40. Draw a map using bearings, distances, and coordinates. (Assignment Sheet 6)
41. Lay out the property boundary for the MAVCC topographic survey map. (Assignment Sheet 7)

Information Sheet

Objective 1

Terms and definitions

a. **Azimuth**—The horizontal direction reckoned clockwise from the meridian plane; usually measured in degrees, minutes, and seconds from 0° to 360°

b. **Back bearing**—Bearing of a station to a preceding station

c. **Backsight**—Sighting that is taken from the survey instrument back to an existing point of elevation

d. **Base line**—A surveyed line, normally straight, with measured increments called stations; often used for control work on engineering projects and as a method of collecting existing ground features

e. **Beaman arc**—A specially graduated arc attached to the vertical circle of an alidade or transit to simplify computing elevation difference for inclined stadia sights

f. **Bearing**—The direction of the line expressed by the acute angle with respect to a reference meridian which can be north or south

g. **Benchmark**—A relatively permanent material object, natural or artificial bearing a marked point whose elevation above or below an adopted datum is known

h. **Blunder**—A mistake due to human error that can be discovered unless negligible

Example: Transposing figures while recording

i. **Circumference**—The calculated or measured distance around a circular object

j. **Course**—The bearing or azimuth and length of a line

k. **Datum**—Any numerical or geometric quantity or set of such quantities which may serve as a reference or base for other quantities

l. **Elevation**—The vertical distance from a datum, generally mean sea level, to a point or object on the earth's surface

m. **Field book**—The common term for the collection base of all field data; usually either a bound booklet or a loose-leaf binder-type book

Note: Various styles and sheet types will be discussed later in the text.

n. **Foresight**—Sighting a point forward of the survey instrument

o. **Grid**—A series of measured parallel and perpendicular reference lines laid out an equal distance apart to form equal squares

p. **Horizontal angle**—The difference in direction between two intersecting vertical planes, or two intersecting lines of sight; usually measured in degrees, minutes, and seconds

q. **Horizontal length**—The straight line distance measured in a horizontal plane

r. **Hub**—A substantially square stake, usually driven flush with the ground, with a tack marking the survey point

s. **Latitude and departure**—The position of a point, line, traverse, triangulation, or grid can be defined by coordinates which are northerly or southerly (latitudes), measured from an arbitrarily chosen east-west (x) axis, and easterly and westerly (departures) measured from an arbitrarily chosen north-south (y) axis

t. **Monument**—A physical structure, such as an iron post, marked stone, or tree in place, which marks the location of a corner point established by a cadastral survey

u. **Parameter**—A set of physical properties whose values determine the characteristics of a system

v. **Point**—A common surveying abbreviation which represents an accurate position of a surveyed station

w. **Reconnaissance**—A normal preliminary stage of a project used to evaluate approaches to surveying projects, collect preliminary data, and familiarize oneself with the site

x. **Recorded**—A surveying term used to signify writing down or transcribing field data into a field book

y. **Station**—Arbitrary points established in a survey usually located 100 feet apart

Note: An instrument setup point is often referred to as a station.

z. **Surveying**—The science of determining the dimensions and contours of the earth's surface by measurements of distances, directions, and elevations; computations of areas and volumes; and the preparation of necessary maps

aa. **Traverse**—A number of points (called traverse stations) connected in series between horizontal angles by horizontal lengths; may be open or closed

bb. **Traversing**—A surveying procedure used to determine the direction and length of a series of lines known as courses

cc. **Triangulation**—A series of connecting triangles in which a side of one and the angle of all are measured and the remaining sides are computed by trigonometry

dd. **Vertical angle**—The difference in direction between a horizontal plane and an intersecting line, plane, or a line of sight to a point

ee. **Vertical length**—A measurement of a difference in height or elevation

Objective 2

Six activities identified by the International Federation of Surveyors that help define surveying

Note: These activities may occur either on, above, or below the surface of the land or the sea, and may be carried out in association with other professionals.

a. Determination of the shape of the earth and measurement of all facts needed to determine the size, position, shape, and contour of any part of the earth's surface, and the provisions of plans, maps, files, and charts recording these facts

b. Positioning of objects in space, and positioning of physical features, structures, and engineering works on, above, or below the surface of the earth

c. Determination of the positions of boundaries of public or private land, including national and international boundaries, and registration of those lands with appropriate authorities

d. Design, establishment, and administration of land and geographic information systems, collection and storage of data within those systems, and analysis and manipulation of that data to produce maps, files, charts, and reports for use in the planning and design processes

e. Planning of the use, development, and re-development of property, and management of that property, whether urban or rural, and whether land or buildings, including determination of values, estimation of costs, and the economic application of resources such as money, labor, and materials taking into account relevant legal, economic, environmental and social factors

f. Study of the natural and social environment, measurement of land and marine resources, and the use of this data in planning and development in urban, rural, and regional areas

Objective 3

Classifications of surveys

a. Geodetic surveying

- Survey adjusted for the curved shape of the earth's surface that establishes a network of reference points in the U.S.A. for precise information on horizontal and vertical locations
- Usually performed by government agencies

  Example: National Geodetic Survey (NGS)
- Survey of high order of accuracy
- Measurements are located by global positioning system (GPS)

b. Plane surveying

- A survey that considers the earth to be a flat surface
- Used for smaller areas of land such as farms, subdivisions, highways, and construction
- Lower order of accuracy

Information Sheet

Objective 4

Types of surveys

a. **Control survey**—Establishes a network of horizontal and vertical monuments that serve as a reference framework for other surveys

b. **Topographic survey**—Determines artificial and natural land features locations and elevations used in map making for topographic maps

c. **Land boundary surveys**—Closed surveys to establish property lines and corners

   Examples: ALTA/ACSM land title survey, design survey

d. **Cadastral survey**—Generally used for surveys of the public lands system

e. **Hydrographic survey**—Defines shorelines and depths of lakes, streams, oceans, and reservoirs

f. **Route survey**—Involves the plan, design, and construction of highways, railroads, pipelines, and other lineal projects which align with the state plane coordinate system

   Note: A route survey may not close on itself, but it always ties back to a known point (i.e. section corner).

g. **Construction survey**—Provides for location of structures, required elevation points for construction and earthwork quantities but not limited to buildings; may involve long surveys such as pipelines

h. **As-built survey**—Made after the construction project is complete to provide the position and dimensions of features of the project as constructed

i. **Geological and forestry survey**—Used in the preparation of geological maps and forest management

j. **Mine survey**—Used to determine relative elevation and position of underground shafts, geological formations, earthwork quantities, and to establish lines and grades

k. **Marine survey**—Similar to hydrographic survey but covers larger area

l. **Photogrammetric survey**—Done by use of aerial photographs in conjunction with limited ground survey that involves panel points; ideal for lands with limited access

m. **Satellite survey**—Determination of ground location from measurements made to satellites using GPS receivers; used to survey large areas

Objective 5

Types of computer-based digital data files

Note: This topic will be covered in greater depth in Unit 8: Municipal Mapping, Plats, and Subdivisions.

a. Land Information Systems (LIS's)—Focus is directed toward land records data (land description, land improvements, etc.)

b. Geographic Information Systems (GIS's)—Focus is on a broader range of data

Note: All types of surveys will be used to support these information systems.

Objective 6

U.S. government agencies that perform surveying

a. National Geodetic Survey (NGS)

b. National Ocean Survey (NOS)

c. Bureau of Land Management (BLM)

d. U.S. Geological Survey (USGS)

e. Defense Mapping Agency (DMA)

f. Corps of Engineers

g. U.S. Army

h. National Park Service

i. Department of Transportation

Objective 7

Types of measurements used in surveying

a. Horizontal angles

b. Horizontal distances

c. Vertical angles

d. Vertical distances

e. Slope distances

Objective 8

Important characteristics in surveying measurement

a. Units of measurement

- Length
- Area
- Volume
- Angle

b. Measuring systems used in surveying

- English—Basic unit is the foot
- Metric (SI)—Basic unit is the meter

Note: 1′ = 0.3048 m

c. Accuracy in a recorded measurement is attained by the number of digits (significant figures) recorded

Note: The number of significant figures in any measured value includes the positive digits plus one digit that is estimated or rounded off.

d. Rules for rounding off numbers

- When a digit to be dropped is lower than 5, the number is written without the digit.

  Example: 88.374 becomes 88.37

- When the digit to be dropped is greater than 5, the number is written with the preceding digit increased by 1.

  Example: 88.376 becomes 88.38

e. Direct and indirect measurements

- Direct measurements—Applying an instrument directly to the quantity to be measured
- Indirect measurement—The measurement is determined by its relationship to some other measured value

  Note: Many indirect measurements are made in surveying.

f. Accuracy of measurement depends on

- Scale's division size
- Reliability of equipment
- Human limitations

Objective 9

Accuracy and precision

Note: In surveying, the terms accuracy and precision can easily be confused if their meanings are not thoroughly understood.

a. Accuracy—Denotes the absolute "nearness" of the measured value to the true value

Example: A wall is measured with a tape and found to be 89.24'. The actual wall was constructed at 89.25'. Consider this an "accurate" measurement.

b. Precision—Refers to the degree of refinement used in measuring a value, either by the number of times measured or by the degree of graduation it was measured in

Example: The same wall was measured three times and the distances recorded: 89.25, 89.24, and 89.25 which were then averaged with the result being 89.247'. This is a more "precise" measurement than the previous one.

Note: On good surveys, precision and accuracy are consistent throughout all stages of work.

Objective 10

Accuracy ratio

a. The accuracy of a measurement or a series of measurements is the ratio of error in the measurement to the distance measured.

b. Error of closure is the difference between the measured location and the theoretically correct location of the same point.

Example: A distance was measured and found to be 250.56 ft. The distance was previously known to be 250.50. This is an error of 0.06 ft.

Accuracy ratio = $\frac{0.06}{250.50} \div \frac{0.06}{0.06} = \frac{1}{4175} = \frac{1}{4200}$ ⊛ rounded

c. This is used to determine the order of accuracy of work that was performed.

Objective 11

Types of errors

a. Systematic errors also known as "cumulative errors" are defined as errors whose magnitude and algebraic sign can be determined. The fact that these errors can be determined allows the surveyor to eliminate them either by calculation or adjustment.

Examples of systematic errors in surveying:

- Slope in measurement
- Erroneous tape length
- Temperature variations
- Improper tension

b. Random errors are beyond the control of the surveyor and are associated with the skill and vigilance of the surveyor. They follow the laws of probability and are often called "accidental or compensating errors."

Examples of random errors in surveying:

- Improper plumbing
- Faulty marking
- Incorrect reading or interpolation
- Misalignment

c. Mistakes or blunders consist of errors or mistakes made by survey personnel. Mistakes will occur but should be discovered and eliminated.

Examples of common mistakes made by personnel:

- Transposing figures (e.g. writing 68 instead of 86)
- Miscounting full tape lengths
- Measuring to or from the wrong point
- Arithmetic mistakes

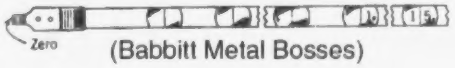
Objective 12

Types of surveying equipment and their uses

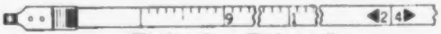
a. **Tapes**—Used to measure horizontal distances

- Steel tapes—50 ft., 10 m, 100 m, 200 m

Figure 1



(Babbitt Metal Bosses)

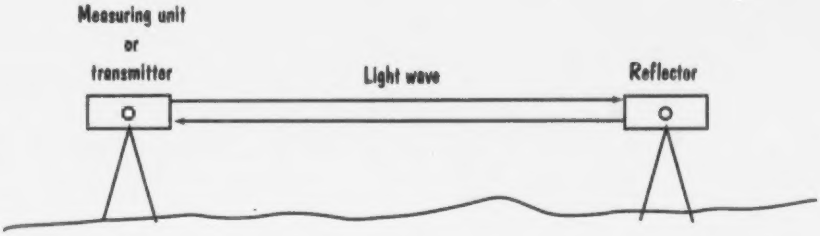


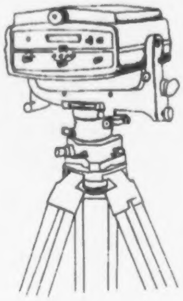
(Etched or Painted)

- Metallic or woven tapes—Invar, nylon, steel
- Chain—66 ft., 100 ft., 200 ft., 300 ft., 30 m, 50 m, 100 m

b. **Electronic distance meter (EDM)**—Emits a signal of electromagnetic energy from a position to a receiver at another position. The signal is returned from the receiver to the instrument such that two times the distance between the two positions can be measured.

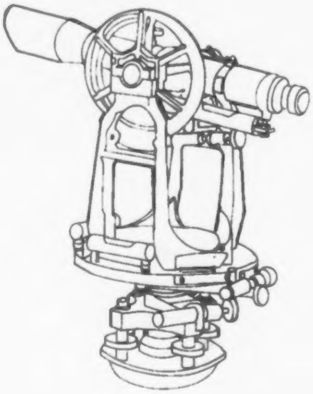
Figure 2


Measuring unit
or
transmitter
Light wave
Reflector



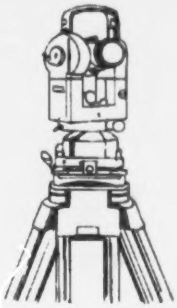
c. **Transit**—Used primarily for measuring horizontal or vertical angles, prolonging and setting points in line, measuring approximate distances by the stadia principles, and for leveling operations

Figure 3



d. **Theodolite**—Accomplishes the same tasks as a transit through optical means that are more accurate

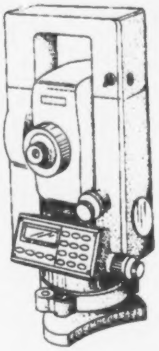
Figure 4



e. **Total station (Electronic tachometer)**—Measures distance and direction simultaneously and transmits the results automatically to a built-in computer

Note: This instrument combines an EDM instrument, an electronic digital theodolite, and a computer into one unit.

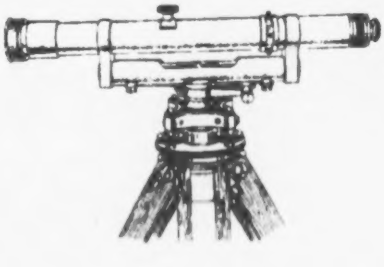
Figure 5



f. **Levels**—Used to establish the elevation of different points on the ground

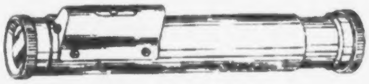
- Dumpy level

Figure 6



- Hand level

Figure 7



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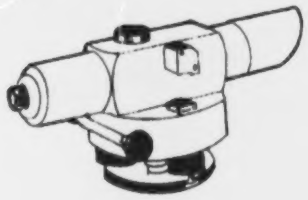
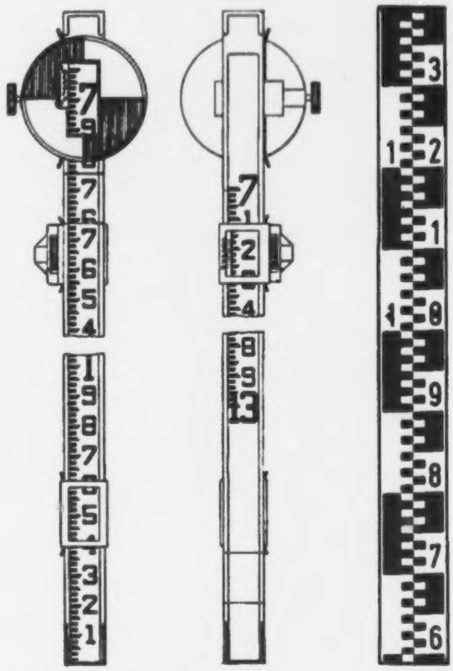
- Self-leveling level

Figure 8



g. **Level rod**—A straight rod or bar with a flat face graduated in linear units with zero at the bottom, used in measuring the vertical distance between a point on the ground and the horizontal line of sight of a leveling instrument

Figure 9



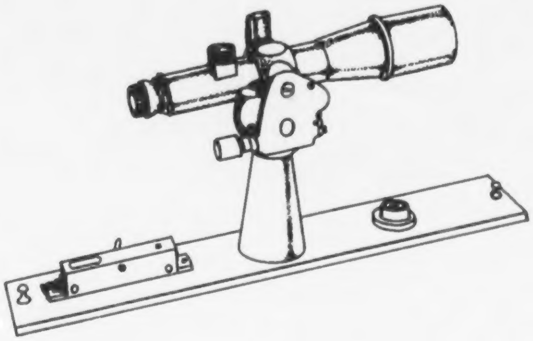
Philadelphia Rod

(Front) (Back)

Metric Rod

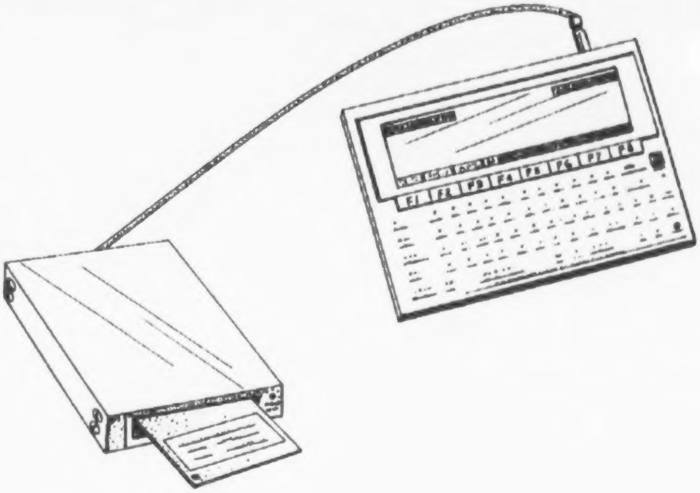
h. **Planetable and alidade**—Used for obtaining detail and topography

Figure 10



i. **Data collector**—Used to collect point locations in the field

Figure 11



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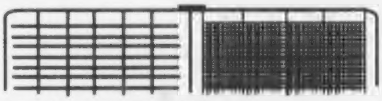
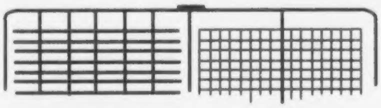
j. **Field books**—Used for recording survey notes and layout and construction data

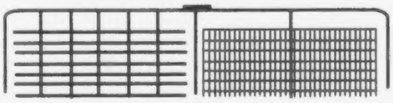
Figure 12



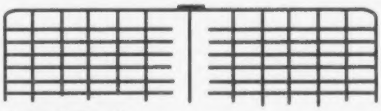
Engineer's Field Book
Left page: Blue horizontal lines; red vertical lines. Right page: 10 x 10 blue lines; red vertical center line. Inch lines heavy.



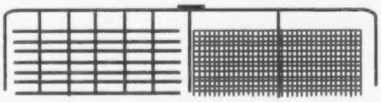
Field Book
Left page: Blue horizontal lines; red vertical lines. Right page: 4 x 4 blue line; red vertical center line.



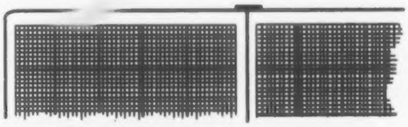
Transit Field Book
Left page: Blue horizontal lines; red vertical lines. Right page: 8 vertical lines and 4 horizontal blue lines; red vertical center line.



Level Book
Both pages: Blue horizontal lines; red vertical lines. 6 vertical columns.



Mining Transit Book
Left page: Blue horizontal lines; red vertical lines. Right page: 8 x 8 blue lines; red vertical center line.



Cross Section Book
Both pages: 10 x 10 blue lines; inch lines slightly heavier.

Objective 13

Methods used in surveying to measure horizontal distances

a. Pacing (Stride)

- One pace equals one step
- One stride equals two paces
- The pedometer or passometer are tools used to measure paces.

b. Odometers and measuring wheels

- Distances regularly measured by rolling a wheel along the ground
- Useful for preliminary survey when pacing would take too long (i.e. route survey)
- Used for quick check measurement

c. Tachymetry

- Means "swift measurement"
- Includes measurements taken by a subtense bar (not replaced by electronic distance measuring devices) or by stadia

d. Stadia

- Measurements can be taken with theodolites, transits, plane-table alidades, and levels
- Rapid and efficient way of indirectly measuring distances and elevation distances
- Lower order accuracy: precision of order—1/250, 1/1000
- Suitable for
  - Topographic details for mapping
  - Backsight and foresight readings in differential leveling
  - Quick checks of measurements in higher order surveys
- Stadia Principle
  - Principle is that in similar triangles, corresponding sides are proportional
  - Transit and theodolite telescopes have three horizontal cross hairs; the top and bottom hairs are called stadia hairs.
  - Sights are read from where the stadia hairs intersect the scaled rod through the telescope.
  - The difference between the two readings is called the rod intercept.

    Note: The ratio for the hair reading to the rod is 100 ft. distance = 1' vertical on the rod (at 200' it is 2 ft. on the rod).

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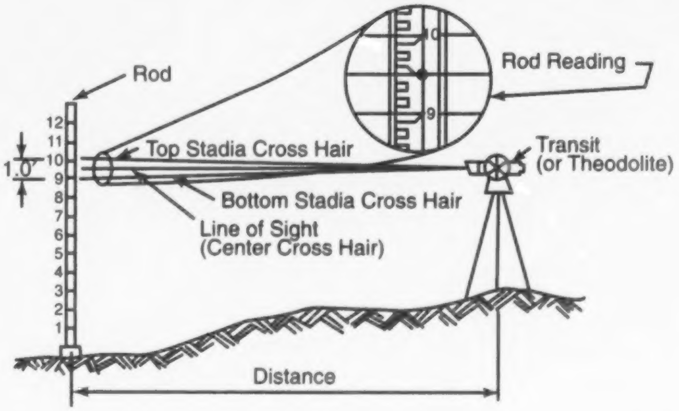
— To determine a horizontal distance the telescope is sighted on the rod and the difference between the top and bottom cross-hair readings is multiplied by 100.

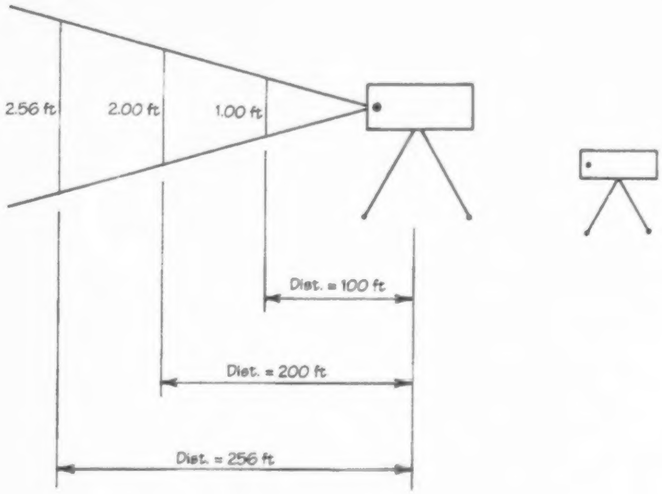
Figure 13


Rod
Rod Reading
10
9
12
11
10
9
8
7
6
5
4
3
2
1
1.0'
Top Stadia Cross Hair
Transit
(or Theodolite)
Bottom Stadia Cross Hair
Line of Sight
(Center Cross Hair)
Distance

— To measure a slope a vertical distance is measured and used to compute the horizontal slope distance.

Note: This can also give the vertical component of the slope distance or the difference between two points.

Figure 14

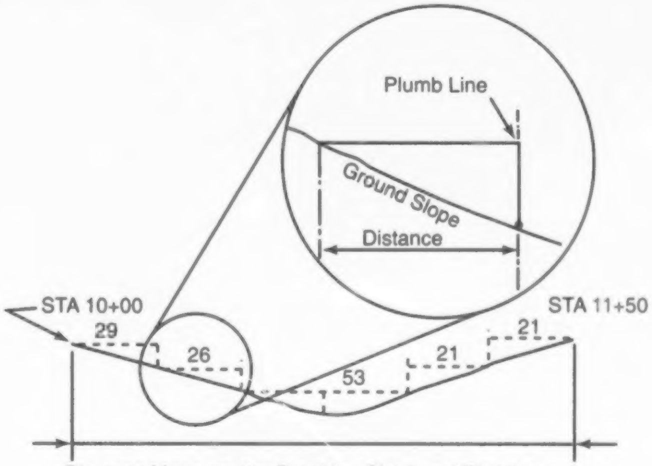

2.56 ft
2.00 ft
1.00 ft
Dist. = 100 ft
Dist. = 200 ft
Dist. = 256 ft

Stadia Readings

e. Taping or chaining

- Chains
  - — Older method of measurement
  - — 66 ft. chain is the most common
  - — 1 acre equals 10 square chains
- Tapes
  - — Lengths available from a few feet up to 1000 ft.
  - — 100′ steel ribbon is the most common length
  - — Precision of 1/1000 to 1/5000
  - — Good for measuring short distances

Figure 15



Distance Measured by Breaking Chain and Plumbing

f. Electronic distance measurement instruments (EDMI's)

Note: The type of measurement and equipment used depends upon required accuracy, access to the line, and time and cost involved.

- Distance measurement is done by measuring the time a wave (light, electromagnetic, infrared or laser) travels to an established point.
- EDMI's
  - — Are useful in measuring distances that are difficult to access
  - — Save time in long distance surveys
  - — Two-person survey crew can work faster than a four-person taping crew
  - — High order accuracy

Objective 14

Methods used to determine horizontal point positions

a. Triangulation

b. Traversing

c. Grid

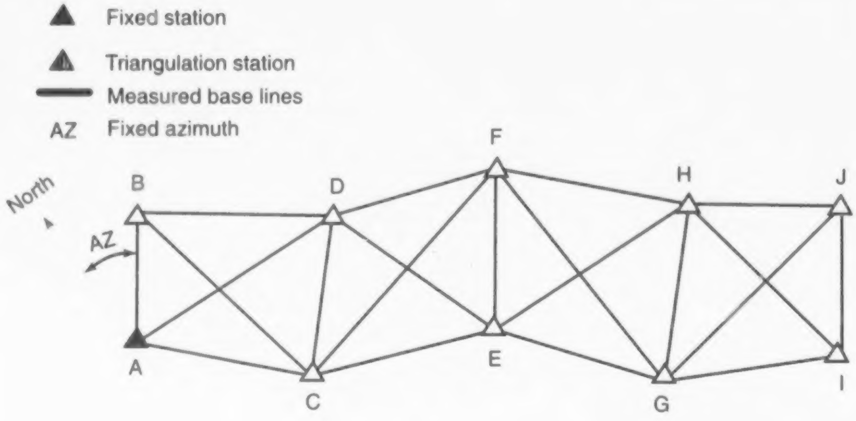
d. Azimuth and bearing

e. Latitude and departure

Objective 15

Triangulation—A method for determining positions of points from which horizontal distances can be computed; length of lines are computed trigonometrically from measured base lines and angles

Figure 16


▲ Fixed station
▲ Triangulation station
— Measured base lines
AZ Fixed azimuth
North
AZ
A
B
C
D
E
F
G
H
I
J

ELEMENTARY SURVEYING 9/E by Wolf/Brinker, ©1998.
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Objective 16

Traverses

a. Consist of a series of lines known as courses.

b. The points where the courses intersect are known as traverse stations.

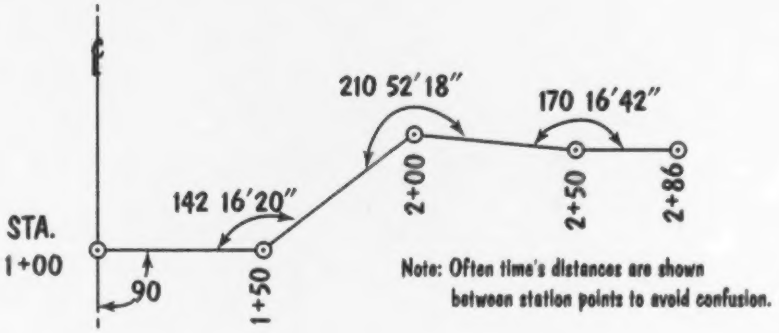
c. The length of the courses are referred to as horizontal distances and given as horizontal angles.

d. Horizontal directions are given in terms of azimuths or bearings.

e. Traverses come in two different types.

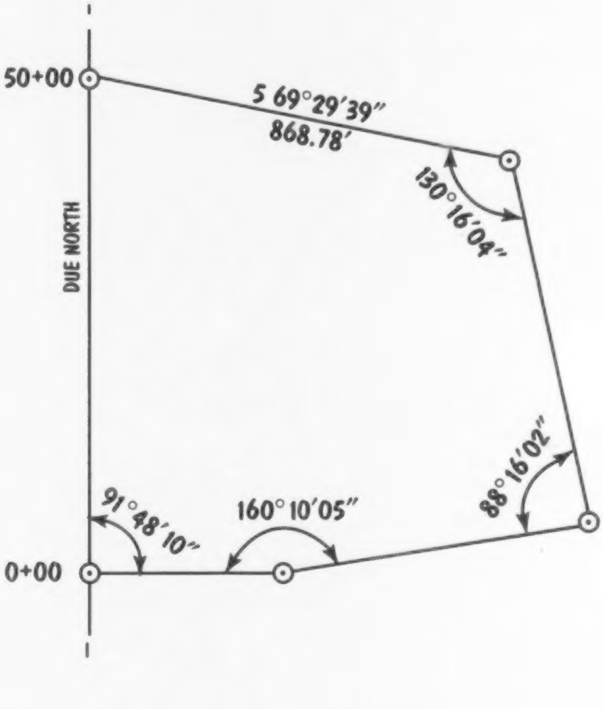
- Open traverse

Figure 17


℄
210 52′18″
170 16′42″
142 16′20″
STA.
1+00
90
1+50
2+00
2+50
2+86
Note: Often time's distances are shown between station points to avoid confusion.

- Closed traverse
  - Loop traverse—Closes on itself

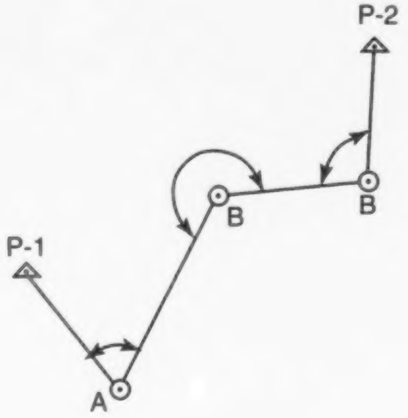
Figure 18


50+00
S 69°29′39″
868.78′
130°16′04″
DUE NORTH
88°16′02″
91°48′10″
160°10′05″
0+00

652

— Connecting traverse—Starts and ends at known locations

Figure 19



Objective 17

Direction of a line/course by bearings or azimuths

a. Bearing direction

- Is an acute horizontal angle which a line makes with the meridian of reference
- Is measured from the north or south end of a meridian
- To determine which side of the meridian the bearing goes, an east or west is added

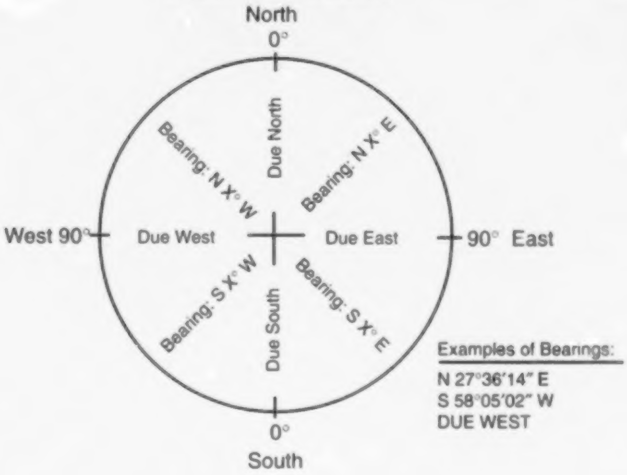
  Example: S 65°07'34" W

  N 35°15'E
- Is measured clockwise or counterclockwise
- Range from 0 to 90 degrees; can never be greater than 90°
- Is expressed in degrees, minutes, and seconds
- Usually established from either a line in which the bearing is known or an astronomical observation
- There are four types of bearings:
  - True bearing—Measures from the true north-south meridian
  - Magnetic bearing—Measures from the magnetic north-south meridian
  - Assumed bearing—Measures from an arbitrary north-south meridian

— Grid bearing—Measures from a central north-south meridian

Figure 20

Direction by Bearing


North
0°
Due North
Bearing: N X° W
Bearing: N X° E
West 90°
Due West
Due East
90° East
Bearing: S X° W
Bearing: S X° E
Due South
0°
South

Examples of Bearings:
N 27°36′14″ E
S 58°05′02″ W
DUE WEST

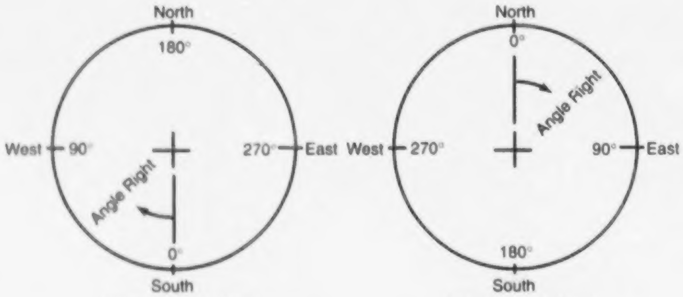
b. Azimuth direction

- Is the direction a line is deflected from either the north or south meridian
- Is measured clockwise only
- Range from 0 to 360°
- Is measured in degrees, minutes, and seconds
- Requires only a numerical value
- The reference meridian is usually north

  Note: South meridian is sometimes used for geodetic surveys that cover large areas.
- The type of meridian system used defines the type of azimuth used
- There are four types of azimuths:
  - True azimuth which measures from the true meridian
  - Magnetic azimuth which measures from the magnetic meridian
  - Assumed azimuth which measures from an arbitrary meridian line

— Grid azimuth which measures from a central meridian in a grid system

Figure 21



Azimuth South (Az_S)
Example: Az_S = 246°07'53"

Azimuth North (Az_N)
Example: Az_N = 66°07'53"

Objective 18

Conversion of azimuths to bearings and bearings to azimuths

a. Converting azimuth to bearing

- An azimuth from north (Az N) between 0° and 90° is in the northeast quadrant. The bearing angle is the same as the azimuth.

  Az N = Bearing

- An azimuth from north between 90° and 180° is in the southeast quadrant. The bearing angle is calculated by subtracting the azimuth from 180°.

  180° - Az N = Bearing

- An azimuth from north between 180° and 270° lies in the southwest quadrant. The bearing angle is calculated by subtracting 180° from the azimuth.

  Az N -180° = Bearing

- An azimuth from north between 270° and 360° is in the northwest quadrant. The bearing angle is calculated by subtracting the azimuth from 360°.

  360° - Az N = Bearing

- An azimuth from north at 0° or 360° has a bearing of due north; an azimuth of 90° has a bearing of due east. An azimuth of 180° has a bearing of due south, and an azimuth of 270° has a bearing of due west.

b. Converting bearing to azimuth

- The azimuth of a line in the northeast quadrant is the same as the bearing angle.

  Azimuth = Bearing

BEST COPY AVAILABLE

- The azimuth of a line in the southeast quadrant is 180° minus the bearing angle.

  180° - Bearing = Azimuth

- The azimuth of a line in the southwest quadrant is 180° plus the bearing angle.

  180° + Bearing = Azimuth

- The azimuth of a line in the northwest quadrant is 360° minus the bearing angle.

  360° - Bearing = Azimuth

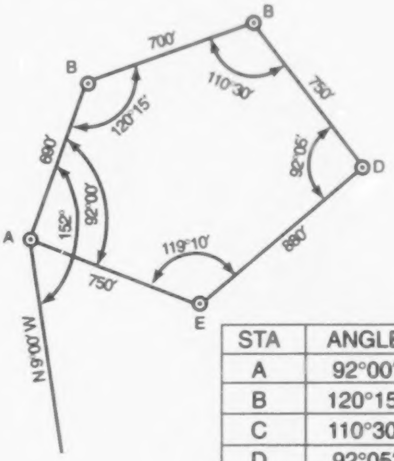
Objective 19

Methods for plotting traverses

a. Interior angles—Three sets of data must be known.

- Location of starting point and its relationship to at least one other traverse course
- The distances of the traverse courses
- The interior angle for each traverse station

Figure 22



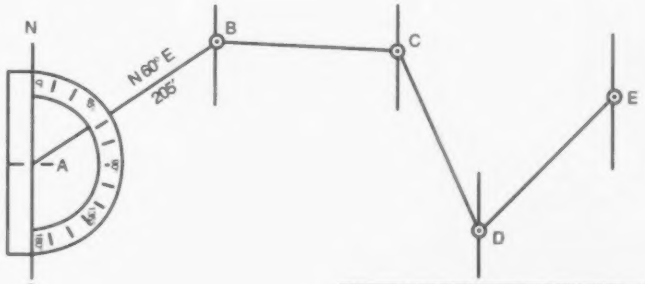
STA	ANGLE	COURSE	DIST
A	92°00′	AB	690′
B	120°15′	BC	700′
C	110°30′	CD	750′
D	92°05′	DE	880′
E	119°10′	EA	750′

Interior Angles Method

b. Distance and bearing

- Is the easiest method
- Plotting is based on the principal of locating traverse stations relative to their bearing to other stations
- Bearings are presented in two formats:
  - Bearing
  - Back bearing
- To plot a traverse by distance and bearing, the distance and bearing/back bearing of each station must be known.

Figure 23



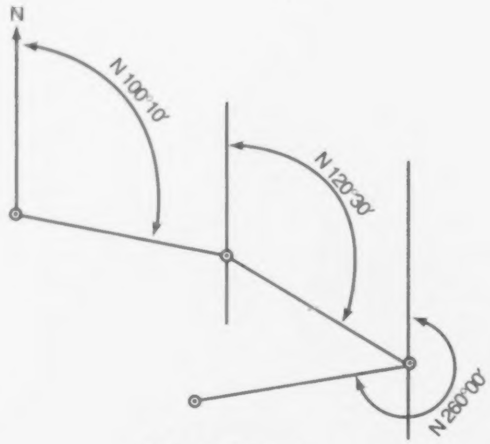
LINE	BEARING	DISTANCE
AB	N 60° E	205′
BC	S 88° E	175′
CD	S 30° E	180′
DE	N 45° E	170′

Distance and Bearing Method

c. Azimuth

- Azimuth traverses present a series of lines that are related to one another by angle measurement only.
- Two sets of data are required.
  - Direction and distance of two known stations from which all azimuth readings are taken
  - Azimuth readings for all traverse points from the two known stations

Figure 24



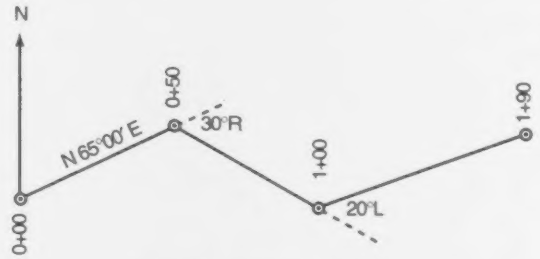
Azimuth Method

d. Deflection angles

- Used to indicate the direction and order of each succeeding traverse course
- Angular measurements are made in a clockwise direction toward the forward direction. A deflection left would be in the counterclockwise direction.
- Deflection angle is the angle between the back course and the forward course.
- Deflection angle indicates the direction change of each traverse course relative to individual traverse stations.
- This method is common in laying out route surveys and utility system construction.

- Advantages for using deflection angles:
  - — Azimuths can easily be calculated
  - — Are used to calculate circular curves in transportation systems
  - — Can be plotted easily

Figure 25



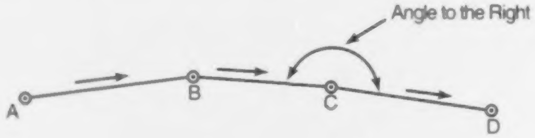
Deflection Angles Method

- When laying out a traverse by deflection angle, the first course is usually located by bearing or azimuth.

e. Angle to the right

- Is a clockwise angle between the preceding line and the next line of a traverse
- It is assumed the survey proceeds from Point A to Point B, then to C and on. The angle to the right is obtained by sighting back to B and measuring the clockwise angle to D.

Figure 26



Angles-to-the-Right Method

f. Latitudes and departures

- Is a common method used in plotting closed traverses
- Latitude of a course is the distance that it extends in a north or south direction

- Courses that run in a northerly direction have a plus (+) latitude and those in a southerly direction have a minus (–) latitude.
- Departure of a course is the distance that it extends in the east or west direction.
- Courses running easterly are (+) plus departures and (–) departures run westerly.
- Calculations to find latitude and departure of a bearing:

  — Latitude = D cos B

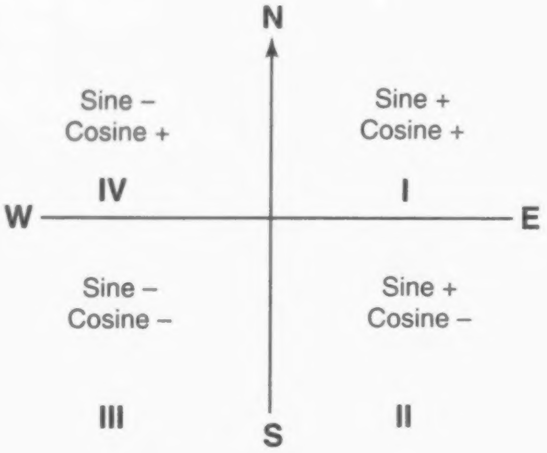
  — Departure = D sin B

  — (D = Distance of course)

  — (A = Azimuth N)

- Using the sine quadrants, the latitudes and departures can be determined by observing where the bearing falls.

Figure 27

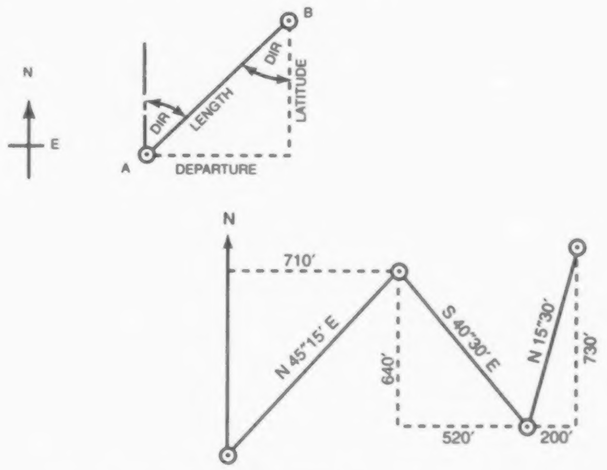


Example: A bearing S 45° E lies in Quad. II.
The latitude would be (–) minus.
The departure would be (+).

600

- Traverses can be plotted by latitudes and departures using a plotting table. The plotting table consists of basic surveying data plus latitudes and departures.

Figure 28



Latitudes and Departures Method
(North) (East)

g. Rectangular coordinates

- Are the most commonly used method of referencing points obtained from a field crew or giving data to a crew.

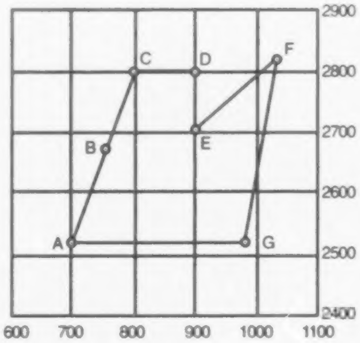
  Note: A northing or easting value can be assumed for small projects, and for large projects they can be based on state plane coordinates, GPS, or local government grid.

- Advantages in using rectangular coordinates:
  - Error in plotting doesn't affect the plotting of succeeding stations.
  - Accuracy of a station location can be checked by measuring its distance to the preceding station.
  - Size of final map can be determined by examining the coordinates.
- The coordinates are based on an X and Y line that are perpendicular to each other.
- The X and Y line can be drawn arbitrarily or drawn to correspond to the meridian.

- If the coordinates are drawn to a meridian, then latitudes and departures are used to plot each point.
- Steps to plot with an arbitrary grid:
  - — Grid lines are drawn (X coordinate [easting], Y coordinate [northing] lines perpendicular to each other).
  - — The lines are spaced at a constant interval.

    Examples: 10, 50, 100, or 500 feet
  - — Spacing of the intervals depends on the scale of the drawing.
  - — Each line is labeled with its designated value.
  - — Each point (station) on a traverse is plotted according to its distance from the nearest grid line.
  - — Accuracy of a station location can be checked by measuring the distance to a preceding station.
- North is considered positive, and south is considered negative.
- East is considered positive, and west is considered negative.

Figure 29



STA	X-COORD	Y-COORD
A	700	2519
B	750	2672
C	800	2800
D	900	2800
E	900	2700
F	1034	2819
G	981	2519

Rectangular Coordinates Method

Objective 20

Vertical angles (zenith)

a. A vertical angle is the difference in direction between two intersecting lines measured in a vertical plane.

b. It is the angle above (+) or below (–) a horizontal plane through the point of observation.

Note: Plus angles are sometimes called angles of elevation and minus angles may be called angles of depression.

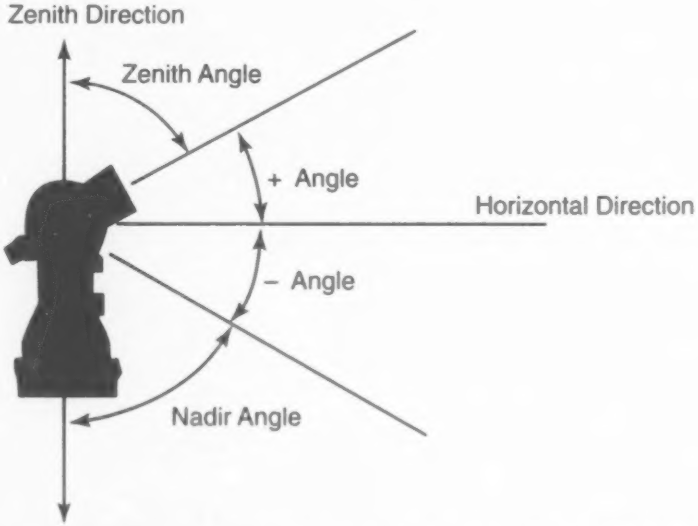
c. Transits measure vertical angles.

d. Theodolites give vertical circle readings called zenith angles.

e. A zenith angle is measured in a vertical plane from the zenith (point directly overhead) to another point from the observer.

f. A nadir angle is measured from a point directly below the observer.

Figure 30



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Objective 21

Definition of leveling—The determination of elevations with a surveying instrument

Objective 22

Basic leveling terminology

a. **Plumb bob**–A pear-shaped weight with a pointed bottom which is suspended on a string or wire to establish a vertical line

b. **Vertical line**—A line parallel to the direction of gravity, the direction assumed by the plumb bob when allowed to swing freely

c. **Level surface**—The surface of a constant elevation that is perpendicular to the plumb line at every point

Note: Plumb bob lines are not parallel to each other at distances apart due to the curvature of the earth, but are assumed to be so in plane surveying.

d. **Elevation**—The vertical distance above or below a reference level surface (normally sea level) of a particular point

e. **Level line**—A curved line in which all points are of equal elevation along a level surface

f. **Horizontal line**—A straight line tangent to a level line at one point

Information Sheet

Objective 23

Reference elevations (datums)

a. Most all surveys use a convenient point as a reference or datum in which other points of elevation may be determined.

b. In the United States, the sea-level datum (the mean or average sea level) is used by surveyors.

c. The National Geodetic Survey and USGS have established a network of known elevations (monuments) throughout the country that are in relation to the sea-level datum.

d. A monument called a benchmark is a point whose elevations have been precisely determined and is usually made of concrete and has a brass disk embedded in it.

Objective 24

Equipment that can be used to level

a. Laser level
b. Tilting level
c. Dumpy level
d. Automatic level (self leveling)
e. Transit
f. Theodolites
g. Total station
h. Level rods

Objective 25

Steps in developing and plotting a profile from profile leveling notes

a. Stakes are set up at regular intervals (range from every 25, 50, 100 feet, depending on regularity of the ground).

b. Station 0+00 is the beginning point. It is always positive relative to a known benchmark (BM).

Note: A known benchmark gives the survey team an exact location and elevation to work from, and allows for mathematical checks for elevation readings.

c. Obtain the elevation at station 0+00.

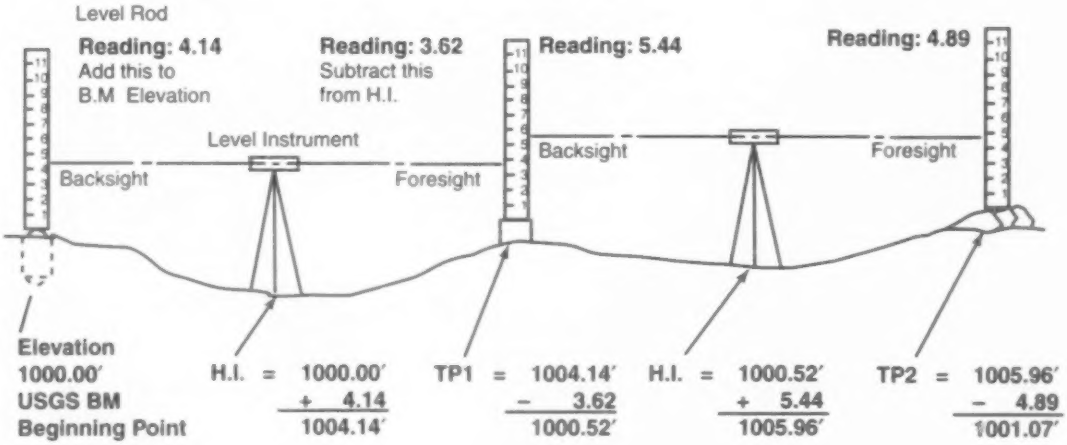
- Level is set near station 0+00 and a plus reading (backsight) is taken from the BM.
- The plus reading is added to the elevation of the BM to give the HI (height of instrument).
- Foresights are then read on as many full station points as can be taken conveniently from the positions of the instrument.
- The foresight readings are subtracted from the HI to obtain the elevations.

d. When necessary to take readings on stations ahead, the level is moved forward to a TP (turning point) or next station and a reading is taken. The reading is subtracted from the HI which gives the elevation of the TP or that station.

- A TP is established when a rod reading exceeds 150 feet or is obstructed from observation dependent on terrain and temperature.
- The first turning point would be labeled TP 1.
- A reading is taken on each TP and subtracted from the HI to give the elevation at that point.

e. Profile leveling should be terminated at another benchmark. Usually the survey returns to the starting point for a check on the error of closure on that survey.

Figure 31


Level Rod
Reading: 4.14
Add this to
B.M Elevation
Reading: 3.62
Subtract this
from H.I.
Reading: 5.44
Reading: 4.89
Level Instrument
Backsight
Foresight
Backsight
Foresight
Elevation
1000.00′
USGS BM
Beginning Point
H.I. = 1000.00′ + 4.14 = 1004.14′
TP1 = 1004.14′ − 3.62 = 1000.52′
H.I. = 1000.52′ + 5.44 = 1005.96′
TP2 = 1005.96′ − 4.89 = 1001.07′

Objective 26

Stationing

a. Survey distances are recorded by stations.

b. Distance between full stations is 100 feet.

c. A fractional part of a full station is called a plus station.

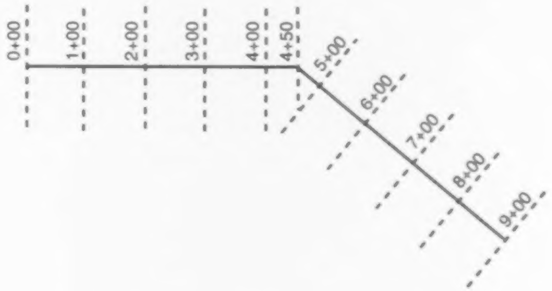
Example: A point on a line 309.20 beyond station 10 + 00 reads as:

$$\underbrace{13}_{\text{Number of full stations}} + \underbrace{09.20}_{\text{Fractional part of a station}}$$

Note: Special care must be taken by the drafter to see what units (feet or meters) are being used.

d. Beginning point in an open traverse is labeled station 0+00.

Figure 32



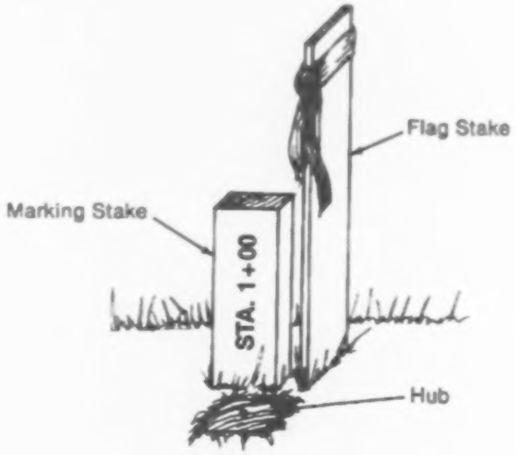
Note: It is recommended to not start the stationing at station 0+00 because later additional information may be required behind the starting point and working with negative stationing is cumbersome.

e. Station point set in the field by a survey crew typically has three stakes.

- Flag stake—A thin long post, commonly referred to as a lathe, with a flag which may be color-coded to mean center of road, edge of road, bottom of bank, etc.
- Marking stake—Indicates station number

  Note: Information can also be given on the marking stake about cut and fill. For example, C-10 means to cut down 10 feet. F-4 means to fill four feet from top of hub.
- Hub—Indicates line, distance, or elevation; now being replaced with 40d or 60d spikes because of durability

Figure 33



666

f. Open traverses are usually numbered with stations from beginning point to end.

Note: On a closed traverse the actual distance between changes in direction of lines are recorded in feet instead of station numbers.

g. Stationing can be assigned to a survey in three ways:

- Continuation of an adjoining survey
- A station from an existing roadway
- Beginning station may be assigned a number and new stationing established. When two lines of stationing come together, an equation is noted.

  Note: It is recommended that all surveys be assigned new stationing. Old stationing should be tied to the new alignment.

Objective 27

Field notes

a. Are the only permanent record of work done in the field

b. Data in field notes is normally used by civil technicians to make drawings or computations.

c. Reinhardt system of upper and lower case slope lettering is used as the lettering style to record notes. All upper case letters are reserved for emphasis.

d. Notes are lettered with a sharp, hard lead pencil such as 3-H or 4-H so an indentation is made in the paper. Lettering used on sketches is arranged so it can be read from bottom of the page or right-hand side.

e. Erasing observed data is not permitted; incorrect entries are crossed out with a single line and the correct entry written in above.

f. If an entire page is to be deleted, diagonal lines are drawn through the page and "VOID" is lettered prominently with the reasons.

g. Field notes are recorded at the time of the survey by a member of the survey crew, usually the party chief.

h. Field notes consist of numerical data, explanatory statements, and sketches.

i. Sketches in field notes are drawn proportionally and with a straight edge using standard mapping symbols. North is at the top or left side.

j. The word "COPY" should be lettered diagonally across pages that are non-original notes.

k. Field notes should be carefully stored as they often are the ultimate authority on a survey.

l. Red ink is used for information added to the field notes later back in the office.

m. Each day's work starts on a clean page.

Note: Field notes are a living document. They should always be referred to for new surveys as they are considered the only legal starting point for a new survey.

n. Instrument number should be recorded with each day's work.

Objective 28

Arrangement of field notes in the field book

a. Field notes should be organized in a form appropriate to the type of survey. Generally, standard forms are used for each of the different types of surveys.

b. Each book should be identified and indexed before recording notes.

- The note book owner's name and address appear on the cover and first inside page in permanent ink.
- All field books are numbered for record purposes.

c. All data pertaining to one survey or project should be entered in the same field book or series of field books.

d. Left and right hand pages are almost always used in pairs.

e. The upper left page or right page must include the following:

- Project name, location, date, time (a.m. or p.m.), and starting and finishing times.
- Weather which is important for applying corrections to tape lengths and for other purposes
- Names and initials of the survey party and their jobs described by symbols.

  Figure 34

  — Instrument operator ⊼

  — Rod person ⌀

  — Notekeeper (or recorder) ≠ ◫ N 🕮

  — Head tape person HT
- Instrument type and number

  Note: The adjustment of the instrument may affect the accuracy of the survey.

f. Each field book must have a table of contents.

g. Pages are numbered in the upper right hand corner of each right-hand page. A single page number is used for both the right and left-hand sides.

h. Notes are run down the page, except in route surveys where they are run up the page to conform with sketches.

i. Each day's work should be on a separate page.

Note: Each type of survey should have a checklist. This checklist should be reviewed before leaving the site of the survey.

Objective 29

Electronically recorded notes

a. Electronically recorded notes are accomplished by the use of a data recorder.

b. Advantages:

- Will work together with other survey instruments to download collected data
- Data may be transferred from field to office with ease
- Free up survey to have extra time for sketches and other non-numerical functions

c. Disadvantage—Potential for this form of data collection not being accepted in a court of law

Objective 30

Global Positioning System (GPS)

a. GPS is a satellite surveying system that is an extremely accurate method of locating points by measuring distances to several artificial satellites that orbit the earth.

b. It is the fastest and most accurate way of locating an object anywhere on the earth.

c. This system was developed, funded, and maintained by the U.S. Department of Defense.

d. The GPS operational constellation consists of 25 satellites (22 navigational, 3 active spares) which orbit the earth in 12-hour orbits.

e. The GPS constellation provides the user with between five and eight usable satellites from most points on the earth.

Information Sheet

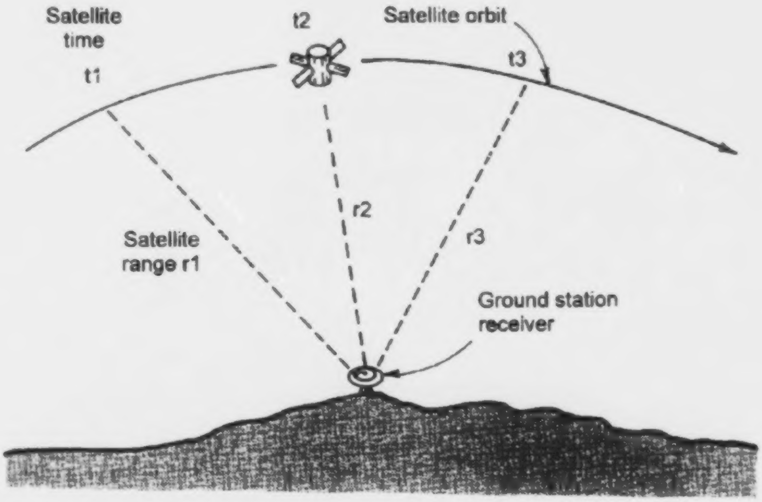
Objective 31

How GPS works

a. GPS consists of measuring distances from points whose location is unknown to satellites whose positions are known at the time the measurements are taken.

b. GPS is a one-way ranging system; the measuring wave is transmitted by satellite as it moves through space and is received by the antenna on the ground.

Figure 35



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c. The measuring wave travels at the speed of light. When a signal is received on the surface of the earth, the time between its transmission and its reception is measured. This time is then multiplied by the speed of light to obtain the distance.

Note: The measurement of distances from one position on earth to artificial satellites is called satellite ranging.

d. The precise location of the GPS receiver is calculated by a complicated mathematical equation. This equation uses angles and distances from the satellites and two known points (the GPS receiver) to determine the distance between these two known points. A minimum of four satellites are utilized for this procedure. With the distance to the four known satellites, these are the four simultaneous equations that are used to solve for a position in the x, y, and z directions.

670

Objective 32

Benefits of surveying with GPS

a. Better accuracy than conventional surveying systems

b. Less room for error

c. Requires fewer personnel; one person unit

d. Not affected by weather; stays on schedule

e. Not affected by time constraints; runs 24 hours a day

- Once point data is established, the receiver may use these points to locate new unknown points.

f. Takes less time than conventional methods

g. Capable of providing both horizontal and vertical coordinates

h. Does not disturb the landscape

Objective 33

General applications of GPS

a. First order triangulation points

b. Control points on government surveys

c. Aerial survey control

d. Route surveys

e. Projects with isolated control points

f. GPS data converts to various types of coordinate systems

Objective 34

GPS procedures

a. Point positioning

- GPS can be used to locate a point using one GPS receiver (lower order accuracy).
- Used along long traverses on a route survey; end points are located by GPS and a few in between to tie the traverse into

b. Distance measuring between two points

- Must start at a known position
- The GPS receiver is placed at each point and the satellites are observed for the same amount of time. The position reading will not be accurate, but the distances between points will be.

Note: The procedure does not require visibility between the two points.

c. Relative positioning

- A GPS receiver is placed at an NCS control point and another placed at a point to be located.
- Four satellites must be visible to obtain latitude, longitude, and azimuth between them and elevation of each point.
- Once point data is established, the receiver may use these points to locate new unknown points.

Student Supplement 1—Measurements and Equivalencies

Linear Measurements				*English Units*			
1 mile	=	5280	feet	1 foot	=	12	inches
	=	1760	yards	1 yard	=	3	feet
	=	320	rods	1 rod	=	16½	feet
	=	80	chains	1 chain	=	66	feet
1 acre	=	43560	ft^2	1 chain	=	100	links
	=	10	square chains				

Linear Measurements		*Metric (SI) Units*	
1 kilometer	=	1000	meters
1 meter	=	100	centimeters
1 centimeter	=	10	millimeters
1 decimeter	=	10	centimeters
1 hectare (ha)	=	10,000	m^2
1 square kilometer	=	1,000,000	m^2
	=	100	hectares

English to Metric Conversion

1 ft = 0.3048 m (exactly)
1 km = 0.62137 miles
1 hectare (ha) = 2.471 acres
1 km^2 = 247.1 acres

1 inch = 25.4 mm (exactly)
1 meter = 3.280833 ft.
(ASCM Standard Metric Conversion)

Note: Prior to 1959, the United States used the relationship 1 m = 39.37 in. This resulted in a U.S. survey foot of .3048006 m.

Student Supplement 2—Error Classification

Source	Type	Cause	Procedure to Eliminate or Reduce
Instrumental	Systematic	Line of sight not parallel to axis of level tube	Adjust instrument; balance sum of backsight and foresight distances
		Rod not standard length (throughout length)	Standardize rod and apply corrections, same as for tape
Personal	Random	Parallax	Focus carefully
		Bubble not centered at instant of sighting	Check bubble before making each sight
		Rod not held plumb	Wave the rod, or use rod level
		Faulty reading of rod or setting of target	Check each reading before recording; for self-reading rod use fairly short sights
		Faulty turning points	Choose definite and stable points
Natural	Random	Temperature	Shield level from sun
	Systematic	Earth's curvature	Balance *each* backsight and foresight distance; or apply computed correction
	Random	Variations in atmospheric refraction	Same as for earth's curvature; also take short sights, well above ground, and take backsight and foresight readings in quick succession
	Systematic	Settlement of tripod or turning points	Choose stable locations; take backsight and foresight readings in quick succession preferably alternating order of sights

Objective 35

Assignment Sheet 1—Plot Lines and Distances Using Several Methods

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Accuracy of measurement	_____
• Neatness of presentation	_____

Basic Skills

Mathematics

Critical Thinking

Directions

Lay out the following problems on vellum with pencil. Discuss the appropriate scale to use with your instructor.

Problem 1

Plotting a traverse by deflection angles

Notes for Traverse 1

Station	Deflection angle	Bearing
29 + 18	End of line	
23 + 98	102°42′ R	
17 + 26	66°21′ R	
12 + 62	37°45′ R	
5 + 25	34°30′ R	
0 + 00		S 50°00′ E

Scale 1″ = 100′

Problem 2

Plotting a traverse by bearings

Notes for Traverse 2

Station	Bearing
25 + 20	End of line
20 + 60	S 45°00′ E
15 + 97	S 70°45′ E
11 + 25	N 80°30′ E
7 + 45	S 81°20′ E
3 + 95	N 83°30′ E
0 + 00	N 60°00′ E

Scale 1″ = 100′

Assignment Sheet 1

Problem 3

Plotting a traverse by latitudes and departures

Notes for Traverse 3

Course	Bearing	Length Chains	Latitude Chains	Departure Chains
5-6	S 30°45′ W	5.53	−4.75	−2.83
4-5	S 70°15′ E	7.77	−2.63	+7.31
3-4	N 25°30′ E	4.62	+4.17	+1.99
2-3	S 65°30′ E	5.25	−2.18	+4.78
1-2	N 45°00′ E	6.00	+4.24	+4.24

Determine the Appropriate Scale

676

Objective 36

Assignment Sheet 2—Convert Azimuths to Bearings and Bearings to Azimuths

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Accuracy of measurement	______
• Neatness of presentation	______

Basic Skills

Mathematics Critical Thinking

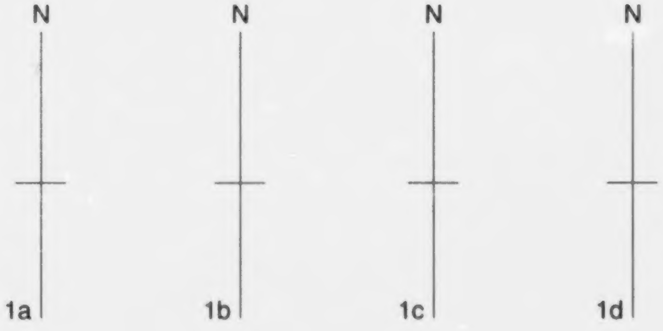
Directions

Convert the following bearings to azimuths north or south or azimuths to bearings as directed. Plot all answers in the space provided using a scale of 1" = 50 ft. and a length of line as 100 ft. Label the line with the appropriate answers.

Problem 1

Convert bearings to azimuths north.

Problem	*Bearing*
1a	S 79°24′ E
1b	N 41°59′ W
1c	N 12°57′ E
1d	S 80°48′ E



Assignment Sheet 2

Problem 2

Convert bearings to azimuths south.

Problem	*Bearing*
2a	S 16°56′ E
2b	S 01°59′ W
2c	N 79°11′ W
2d	S 43°08′ E

Problem 3

Convert azimuths to bearings. Label the line with the true bearing.

Problem	*Azimuth (N)*
3a	144°51′
3b	217°24′
3c	185°37′
3d	346°14′

Objective 37

Assignment Sheet 3—Lay Out a Closed Traverse

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	**Rating**
• Precision of plotting layout	______
• Accuracy of measurement	______
• Neatness of presentation	______

Basic Skills

Mathematics

Critical Thinking

Given: Field notes for a closed traverse. Distances were measured in the field and direction of each line was measured by an azimuth from the north. The field notes are from a traverse that has been adjusted to give mathematical closure and the resulting plotted traverse should return to the point of beginning.

Directions

1. Use a scale of 1" = 100' and "C" size vellum and pencil.
2. Plot this traverse by use of the distances and calculated bearings shown in column 2 and column 6 of the given field notes.
3. Begin traverse at point M at approximately 1 inch from the top of your sheet and 1/2 inch from the left. The first line of the traverse begins at point "M" and extends to a point 13 488.32 feet at a bearing of S 83°56" E.
4. After laying out the closed traverse, label all lengths by bearing and distance and label each station. Use 1/16 open circle to locate each station.

Explanation for column headings in the field notes

Column 1—"Sta."—Station at which the surveying instrument is set up. (Transit in this example)

Column 2—"Obj."—This column gives the object to which the measurement was made.

Column 3—"Dist Ft"—The distance between each point on the traverse.

Column 4—"Azimuth"—The direction of each line measured by an azimuth from the north.

Column 5—"Mag. B"—The compass bearing for each line recorded as a check on mistakes in recording or reading the azimuths.

Column 6—"Cal. B"—The calculated bearings for each line that was obtained from converting the azimuths to bearings.

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Notes for Plate 2

Azimuth Control Traverse

Sta.	Obj.	Dist. Ft.	Azimuth	Mag. B	Cal. B.
M	N		150°23'	S29⅝°E	S29°37'E
	13	488.32	96°04'	S84°E	S83°56'E
13	M		276°04'	N84°W	N83°56'W
	14	545.44	93°01'	S87°E	S86°59'E
14	13		273°01'	N87°W	N86°59'W
	15	525.88	82°19'	N82¼°E	N82°19'E
15	14		262°19'	S82¼°W	S82°19'W
	16	134.95	82°49'	N82¾°E	N82°49'E
16	15		262°49'	S82¾W	S82°49'W
	T	98.51	108°11'	S71¾°E	S71°49'E
T	16		288°11'	N71¾°W	N71°49'W
	U	403.97	184°52'	S5°W	S4°52'W
U	T		4°52'	N5°E	N4°52'E
	V	195.57	178°40'	S1⅓°E	S1°20'E
V	U		358°40'	N1⅓°W	N1°20 W
	W	210.67	181°41'	S1¾°W	S1°41'W
W	V		1°41'	N1¾°E	N1°41'E
	X	76.26	184°57'	S5°W	S4°57'W
X	W		4°57'	N5°E	N4°57'E
	Y	706.96	277°24'	N82½°W	N82°36'W
Y	X		97°24'	S82½°E	S82°36'E
	Z	345.07	268°37'	S88⅝W	S88°37'W

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South City Park, Opelousas, La.

Gurley Transit
No. 601652

J. Zeranges, ⊼
A. Soileau, N.C.
G. Carrier, R.C.
June 17, 1964
Wx. Hot-Clear

Note:
1. Azimuth from North
2. Azimuth of line M-13 determined with Gurley Solar Transit 112F, No. 600500
3. Declination determined to be 7½° East. Compass ring set for needle to read true bearings
4. Hubs set and tacked at corners.

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Assignment Sheet 3

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Notes for Plate 2 con't.

Sta.	Obj.	Dist. Ft.	Az.	Mag. B	Cal. B.
Z	Y		88°37'	N88½°E	N88°37'E
	C	417.72	268°37'	S88½W	S88°37'W
C	Z		88°37'	N88½°E	N88°37'E
	B	228.73	359°20'	N0½°W	N0°40'W
B	C		179°20'	S0½°E	S0°40'E
	A	99.87	0°00'	North	North
A	B		180°00'	South	South
	N	383.47	332°45'	N27¼°W	N27°15W
N	A		152°45'	S27¼°E	S27°15'E
	M	191.35	330°23'	N29¼°W	N29°37'W
M	N		150°23'	S29¼°E	S29°37'E
	Az.	Error	0°00'		

ll

Capped pipe set in concrete

Capped pipe set in concrete

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Objective 38

Assignment Sheet 4—Complete a Mathematical Closure of a Traverse

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Accuracy of calculations	______
• Correctness of posting in chart	______

Basic Skills

Reading Mathematics Critical Thinking

There will be times when platting a new subdivision or other parcel of land that an error will be indicated because of failure to close property and the drafter cannot find the error. In order to check the drafting, the traverse can be checked mathematically on paper indicating whether or not the bearings (or angles) and distances given are correct. This method can also be used in the case of a figure with any number of sides where all the sides but one are known to find the bearing and distance of the remaining side to close the figure.

Mathematical closure of a traverse is merely a system of converting each side of the figure (figure can contain any number of sides but they must all be straight lines) into either north or south bearings and east or west bearings.

Before proceeding with any traverse closure, the angles or bearings must be checked to see that the figure closes as far as angles are concerned. These angles should all be checked in the field by the survey crew before they return to the office and the error balanced.

The procedure for checking a traverse is as follows:

1. Check interior angles. Sum of interior angle = (N - 2) x 180°.
2. Assume one side as being true north bearing unless bearings are already given.
3. Using balanced interior angles and side assumed as north, determine the bearing of the other sides. Be sure to recheck the bearing of the first side from the last side determined to eliminate errors.
4. Assign numerals in consecutive order from the point of beginning chosen (P.O.B.) for each angle point in traverse.

5. Fill in all known data on computation sheet (side, bearing, distance).

6. Calculate the sine and cosine for each side from bearing indicated.

7. Multiply the length of each side by the sine and insert the result in either the east or west Departure Column that matches the bearing.

8. Multiply the length of each side by the cosine and insert the result in either the north or south Latitude Column that matches the bearing.

9. Add up the north latitudes and compare this with the sum of the south latitudes. If the traverse is correct, the two will be equal.

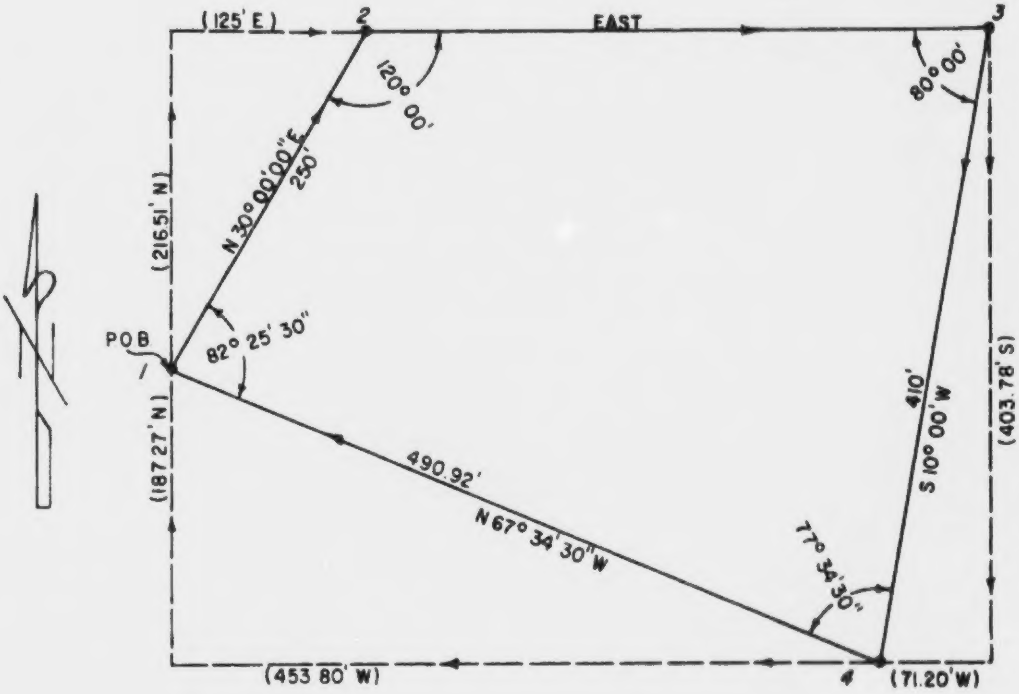
10. Add up the east departures and compare this with the sum of the west departures. They should also be equal.

11. Engineers and surveyors doing subdivision work generally use transits that read horizontal angles to the nearest minute or nearest 1 second. This means that when they balance their angles in the field, the resulting angles may be given to the nearest 15 or 30 seconds. The check of a closure is a simple process but care must be taken with decimal points and to see that the latitudes and departures are entered in the correct columns. Bearings are always given from north or south (unless due east or west) and are always less than 90°.

Example:

Traverse Closure

120° 00′
80° 00′ N − 2 (180) = 4 − 2 (180)
77° 34′30″ = 2 (180)
82° 25′30″
359° 59′60″ = 360° CHECK = 360°


(125' E)
2
EAST
3
120° 00'
80° 00'
N 30° 00' 00" E
250'
(216.51' N)
POB
1
82° 25' 30"
(187.27' N)
490.92'
N 67° 34' 30" W
410'
S 10° 00' W
(403.78' S)
77° 34' 30"
(453.80' W)
4
(71.20' W)

Assignment Sheet 4

Course	Dist.	Bearing	SIN	COS	LAT.		DEP.	
					N (+)	S (–)	E (+)	W (–)
1								
	250.00	N 30°00′ E	.500 00000	.866 02540	216.51		125.00	
2								
	400.00	Due East					400.00	
3								
	410.00	S 10°00′ W	.173 64818	.984 80775		71.20		403.77
4								
	490.92	N 67°34′30″ W	.924 37967	.381 47375	453.80			187.27
1								
					403.78	403.77	525.00	525.00

12. Total Error (TE) = $\sqrt{(\text{Diff. in Lat.})^2 \div (\text{Diff. in. Dep.})^2}$

13. Relative Error = (Precision) $\dfrac{\text{Total Error}}{\text{Total Dist.}} = \dfrac{1}{?}$

Note: The degree of accuracy required of a survey is determined by the purpose of the survey.

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Assignment Sheet 4

Directions

1. Lay out the following traverse.

Course	Bearing	Distance
A-B	N 48°20′ E	529.60
B-C	N 87°43′ E	592.0
C-D	S 7°59′ E	563.6
D-E	S 82°12′ W	753.4
E-A	N 48°12′ W	428.2

2. Using the completed traverse, calculate the mathematical closure of the traverse.

Course	Dist.	Bearing	SIN	COS	LAT.		DEP.	
					N (+)	S (—)	E (+)	W (—)
A-B								
B-C								
C-D								
D-E								
E-A								

3. Calculate the total error and the relative error.

TE = ____________

RE = ____________

Objective 39

Assignment Sheet 5—Reduce Four Types of Field Notes

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Mathematical accuracy	______
• Procedural accuracy	______

Basic Skills

Mathematics Critical Thinking

Given: Examples of the following field notes and mathematical reductions for each type:

- Differential level notes
- Profile level notes
- Miscellaneous level shots at random
- Cross section notes

Directions

Study the examples for procedure and take the assigned field notes and mathematically reduce them.

Assignment Sheet 5

Sample

Typical Field Notes: Differential level
Field notes as given to the drafter by the surveyor

①	SAMPLE : DIFFERENTIAL LEVEL					8-22-85 9:15 A.M. CLOUDY, COOL, +68°, WINDY CEC
	B.S.	H.I	FS	ROD	ELEV.	
BM₁	4.14				1000.00	ARBITRARY ELEV. SET ON TOP OF SPIKE IN POWER POLE @ COR. OF 2ND ST. & 10th AVE. NW (PAINTED ORANGE)
TP₁			3.62			
	5.44					
TP₂			4.09			
	6.33					
TP₃			5.37			
	5.11					
TBM(A)			5.06			SPIKE IN POWER POLE @ CORNER OF MOUNTAIN ST. & CHARLES AVE. (PAINTED ORANGE)
	5.16					
TP₄			4.88			
	5.02					
TP₅			3.61			
	5.39					
TP₆			4.84			
	3.02					
BM₁	39.61 →		7.34			SAME AS STARTING BM DESCP (CK BACK IN)
			39.61			
	CK OK					

Drafter's reduction: Differential level
Field notes after they have been mathematically reduced by the drafter

①	SAMPLE : DIFFERENTIAL LEVEL					8-22-85 9:15 A.M. CLOUDY, COOL, +68°, WINDY CEC
	B.S.	H.I	FS	ROD	ELEV.	
BM$_1$	4.14	1004.14			1000.00	ARBITRARY ELEV. SET ON TOP OF SPIKE IN
TP$_1$			3.62		1000.52	POWER POLE @ COR. OF 2ND ST. & 10th AVE. NW
	5.44	1005.96				(PAINTED ORANGE)
TP$_2$			4.89		1001.07	
	6.33	1007.40				
TP$_3$			5.37		1002.03	
	5.11	1007.14				
TBM$_{(4)}$			5.06		1002.08	SPIKE IN POWER POLE @ CORNER OF
	5.16	1007.24				MOUNTAIN ST. & CHARLES AVE.
TP$_4$			4.88		1002.36	(PAINTED ORANGE)
	5.02	1007.38				
TP$_5$			3.61		1003.77	
	5.39	1009.16				
TP$_6$			4.84		1004.32	
	3.02	1007.34				
BM$_1$	39.61		7.34		1000.00	SAME AS STARTING BM DESCP. (CK BACK IN)
			39.61			
	CK OK					

CHK OK
SAME AS STARTING ELEV.

Start with beginning BM, add the 1st Backsight (BS) to get your height of inst. (HI). Subtract your foresight (FS) from the HI to get ground elevation or turning point (TP) elev. Add the next BS to the last elev. to obtain your new HI. (Refer to Transparency Master 2)

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Assignment Sheet 5

Problem 1

Mathematically reduce the following field notes.
Show your figures in red pencil.

⑭	DIFFERENTIAL LEVEL NOTES					10-21-85 8:05 A.M. CLOUDY, WINDY + 38°	CEC RLS
STA.	BS	HI	FS	ROD	ELEV.		
BM_1					1000.00	ARBITRARY ELEV. SET ON TOP NUT OF F.H. @	
	2.55					CORNER OF 3RD AVE. NORTH & 12th ST. WEST	
TP_1			2.78			SHOT ON CURB	
	2.98						
TP_2			3.28			STREET LIGHT BASE	
	3.92						
TP_3			4.79			ON CURB	
	5.04						
TBM_1			5.11			"X" ON N.W. COR. OF FRONT STEP- ENTRANCE	
	5.18					TO SCHERTZ MANUFACTURING	
TP_4			5.09			F.H.	
	5.03						
TP_5			4.77			CURB	
	4.12						
TP_6			3.50			CURB	
	2.95						
BM_1			2.45			SAME AS ABOVE - CHECKED BACK IN.	
	31.77		31.77				
		CK OK					

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Assignment Sheet 5

Typical Field Notes: Miscellaneous level at random
Field notes as given to the drafter by the surveyor

③	SAMPLE: MISC. LEVEL SHOTS @ RANDOM					8-22-85 10:35 AM CLOUDY, +70°, WINDY	CEC
STA	BS	HI	FS	ROD	ELEV.		
BM_1					5966.04	RR. SPIKE IN POWER POLE IN FRONT OF	
	4.88					PADDOCK CENTER 805 GILLESPIE DR.	
				3.61		NW CORNER OF FOUNDATION ON SCHOOL	
				4.20		CURB AT FRONT ENTRANCE TO SCHOOL	
				4.00		℄ OF STREET 20' OUT FROM CURB SHOT	
TP_1			2.66				
	5.39						
				3.72		BOTTOM OF LOADING DOCK (BY BACK DOOR)	
				1.48		TOP OF " " " " "	
TP_2			5.81				
	1.96						
BM_1			3.76			SAME AS ABOVE	
	12.23	———	12.23				
		CK OK					

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Assignment Sheet 5

Sample Solution

Typical Field Notes: Miscellaneous level at random
Field notes after they have been mathematically reduced by the drafter

③	SAMPLE: MISC. LEVEL SHOTS @ RANDOM					8-22-85 10:35 AM CLOUDY, 70°, WINDY	CEC
STA	BS	HI	FS	ROD	ELEV.		
BM₁					5966.04	RR. SPIKE IN POWER POLE IN FRONT OF	
	4.88	5970.92				PADDOCK CENTER 805 GILLESPIE DR.	
				3.61	67.31	NW CORNER OF FOUNDATION ON SCHOOL	
				4.20	66.72	CURB AT FRONT ENTRANCE TO SCHOOL	
				4.00	66.92	℄ OF STREET 20' OUT FROM CURB SHOT	
TP₁			2.66		5968.26		
	5.39	5973.65					
				3.72	69.93	BOTTOM OF LOADING DOCK (BY BACK DOOR)	
				1.48	72.17	TOP OF " " " " "	
TP₂			5.81		5967.84		
	1.96	5969.80					
BM₁			3.76		5966.04	SAME AS ABOVE	
	12.23	←——→	12.23		CK. OK.		
		CK OK					
				SAME AS STARTING ELEV.			

Assignment Sheet 5

Problem 2

Mathematically reduce the following field notes. Show your figures in red pencil.

⑫		MISC LEVEL SHOTS @ RANDOM				9-10-85 2:30 P.M.	T.S. E.G.
						CLEAR, 75°, CALM	
STA	BS	HI	FS	ROD	ELEV.		
BM1					6324.49		N.W CORNER OF LIGHT POLE ON THE
	5.02						CORNER OF 7th ST. AND 4th AVE SW
				2.31			TOP NUT OF FIRE HYDRANT
				1.86			N TAN. SW CORNER OF 7th ST & 4th AVE
				2.55			SE CORNER OF SLAB OF MAILBOX (702)
TP1			1.06			(ROCK)	
	4.28						
				3.44			N INT OF DRWY AND CURB (716)
				1.26			NW CORNER OF FIRST STEP (711)
TP2			4.32			(CURB)	
	.79						NUMBERS IN PARENTHESIS ARE
BM1			4.71			(SAME AS ABOVE)	HOUSE NUMBERS
	10.09	←→	10.09				
		CK OK					

Assignment Sheet 5

Sample

Typical Field Notes: Profile level
Field notes as given to the drafter by the surveyor

②	SAMPLE : PROFILE LEVEL NOTES					8-22-85 9:45 AM CLOUDY, COOL, +65°; WIND	CEC
STA.	BS	HI	FS	ROD	ELEV.		
BM_1					1747.17	U.S.G.S. BM # V-84 SET IN NOV 1964	
	5.18					(N.W. CORNER SECT 5, T115N, R58W)	
0+00				5.02			
0+50				4.85			
1+00				4.71			
1+50				4.16			
2+00				3.58			
2+50				2.96			
TP_1			3.14				
	6.96						
3+00				6.25			
3+50				5.18			
4+00				4.87			
4+50				3.49			
5+00				3.30			
TP_2			5.88				
	2.10						
BM_1			5.22			SAME AS ABOVE	
	14.24	⟷	14.24				
		CK OK				PROFILE SHOTS ON TWSP. ROAD ℄	
						RUNNING EAST FROM THE N.W. COR.	
						OF SECT. 5, T115N, R58W.	

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Assignment Sheet 5

Sample Solution

Typical Field Notes: Profile level
Field notes after they have been mathematically reduced by the drafter

②	SAMPLE : PROFILE LEVEL NOTES					8-22-85 9:45 AM CLOUDY, COOL, +65°; WIND	CEC
STA.	BS	HI	FS	ROD	ELEV.		
BM_1					1747.17	U.S.G.S. BM # V-84 SET IN NOV 1964	
	5.18	1752.35				(N.W. CORNER SECT 5, T115N, R58W)	
0+00				5.02	1747.33		
0+50				4.83	1747.52		
1+00				4.71	1747.64		
1+50				4.16	1748.19		
2+00				3.58	1748.77		
2+50				2.96	1749.39		
TP_1			3.14		1749.21	These elevations in turn would be plotted on profile paper.	
	6.96	1756.17				If plan/profile paper is required, you would	
3+00				6.25	49.92	need topo notes in addition to these.	
3+50				5.18	50.99		
4+00				4.87	51.30		
4+50				3.99	52.18		
5+00				3.30	52.87		
TP_2			5.88		1750.29		
	2.10	1752.39					
BM_1			5.22		1747.17	SAME AS ABOVE	
	14.24 ←	→	14.24		CK. OK.		
		CK OK				PROFILE SHOTS ON TWSP ROAD ℄	
			SAME AS STARTING ELEV.			RUNNING EAST FROM THE N.W. COR.	
						OF SECT. 5, T115N, R58W.	

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Assignment Sheet 5

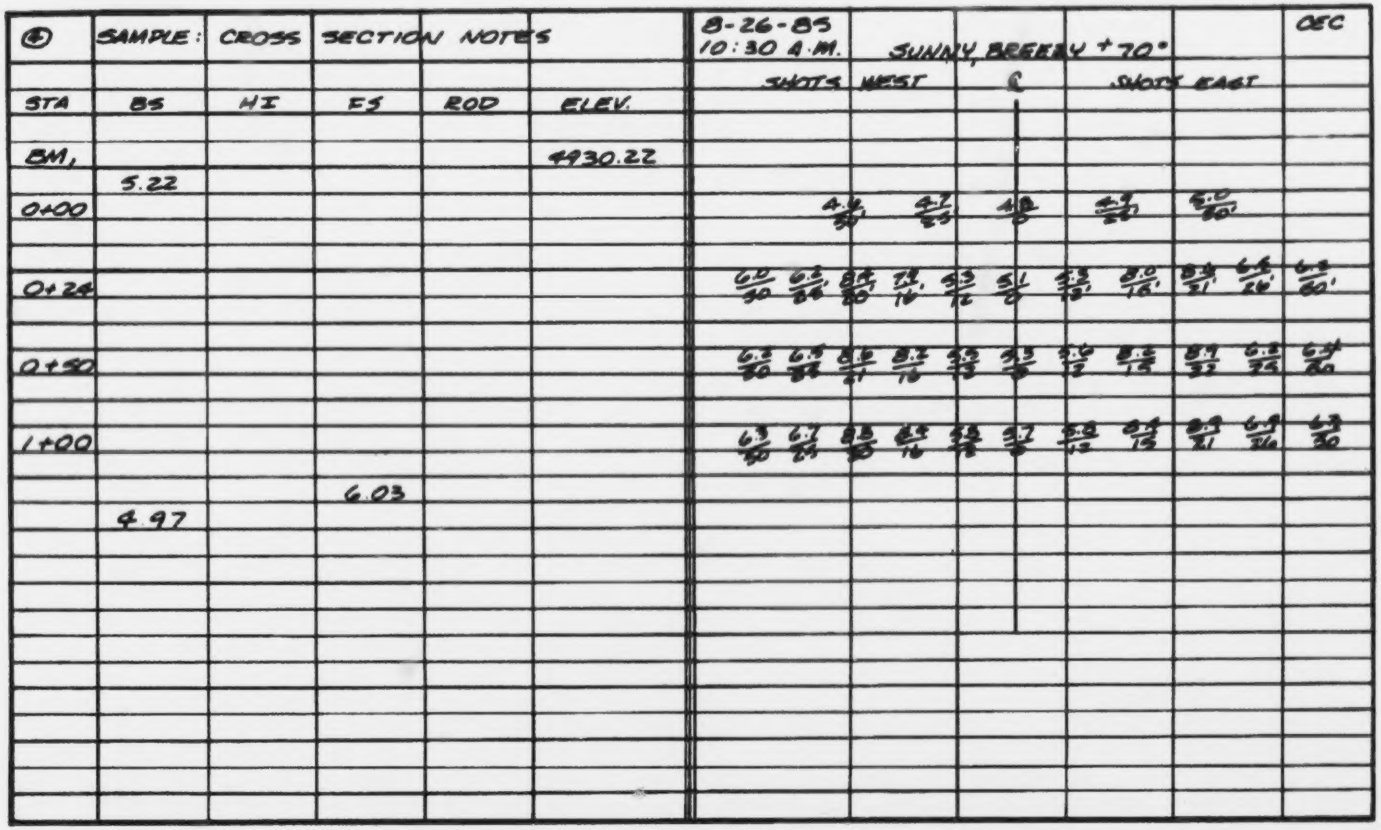
Problem 3

Mathematically reduce the following field notes.
Show your figures in red pencil.

⑧	PROFILE LEVEL NOTES - 10th AVE. NW					8-25-85 9:00 A.M. SUNNY, WINDY, +42°	CEC RLS
STA.	BS	HI	FS	ROD	ELEV.		
BM1					1790.40	STREET LIGHT BASE @ COR. OF 10th AVE. N &	
	5.22					2nd ST. W.	
0+00				3.96			
0+50				4.14			
1+00				4.82			
1+50				5.29			
TP1			5.37			SHOT ON CURB	
	4.10						
2+00				4.80			
2+50				5.21			
3+00				5.96			
3+50				6.33			
TP2			6.05			SHOT ON DRIVEWAY	
	5.30						
4+00				4.94			
4+50				5.62			
TP3			5.10			SHOT ON CURB	
	6.55						
BM1			4.65			SAME AS ABOVE (CHECKED IN)	
	21.17		21.17				
		OK OK					

Assignment Sheet 5

Typical Field Notes: Cross section
Field notes as given to the drafter by the surveyor

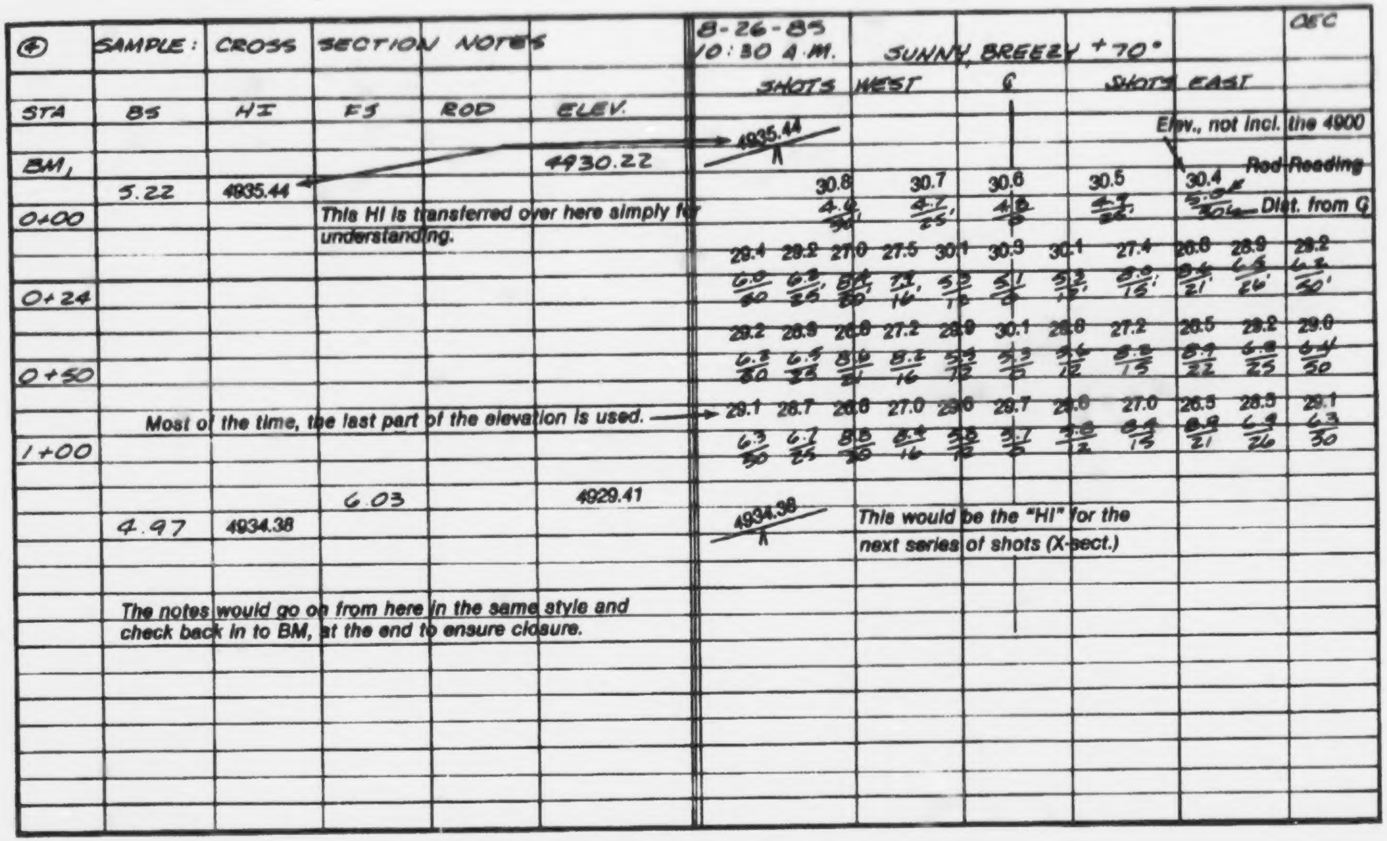


④	SAMPLE: CROSS SECTION NOTES					8-26-85 10:30 A.M. SUNNY, BREEZY +70° OEC
						SHOTS WEST ℄ SHOTS EAST
STA	BS	HI	FS	ROD	ELEV.	
BM,					4930.22	
	5.22					
0+00						4.6/30 4.7/25 4.8/0 4.9/20 5.0/30
0+24						6.0/30 6.2/24 8.5/20 7.9/16 5.3/12 5.1/0 5.3/12 8.0/16 8.4/21 6.6/26 6.0/30
0+50						6.2/30 6.5/24 8.6/21 8.2/16 5.5/13 5.3/0 5.6/12 8.2/15 8.7/22 6.2/25 6.4/30
1+00						6.3/30 6.7/24 8.5/20 8.5/16 5.5/13 5.7/0 5.8/12 8.4/15 8.9/21 6.9/26 6.3/30
			6.03			
	4.97					

Assignment Sheet 5

Sample Solution

Typical Field Notes: Cross section
Field notes after they have been mathematically reduced by the drafter



④ SAMPLE: CROSS SECTION NOTES

STA	BS	HI	FS	ROD	ELEV.
BM,					4930.22
	5.22	4935.44			
0+00					
0+24					
0+50					
1+00					
			6.03		4929.41
	4.97	4934.38			

This HI is transferred over here simply for understanding.

Most of the time, the last part of the elevation is used.

The notes would go on from here in the same style and check back in to BM, at the end to ensure closure.

8-26-85
10:30 A.M.
SUNNY, BREEZY +70°
OEC

SHOTS WEST ℄ SHOTS EAST

4935.44

Elev., not incl. the 4900
Rod Reading
Dist. from ℄

		30.8 4.6/30'		30.7 4.7/25'	30.6 4.8/0	30.5 4.9/25'		30.4 5.0/30'		
29.4 6.0/30	29.2 6.2/25'	27.0 8.4/20'	27.5 7.9/16'	30.1 5.3/12	30.3 5.1/0	30.1 5.3/12'	27.4 8.0/15'	26.8 8.6/21'	28.9 6.5/26'	29.2 6.2/30'
29.2 6.2/30	28.9 6.5/25	26.8 8.6/21	27.2 8.2/16	29.9 5.5/12	30.1 5.3/0	29.8 5.6/12	27.2 8.2/15	26.5 8.9/22	29.2 6.2/25	29.0 6.4/30
29.1 6.3/30	28.7 6.7/25	26.8 8.6/20	27.0 8.4/16	29.6 5.8/12	29.7 5.7/0	29.6 5.8/12	27.0 8.4/15	26.5 8.9/21	28.5 6.9/26	29.1 6.3/30

4934.38

This would be the "HI" for the next series of shots (X-sect.)

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Assignment Sheet 5

Problem 4

Mathematically reduce the following field notes. Show your figures in red pencil.

⑯	CROSS	SECTION NOTES (Co Rd 19)				10-23-85 11:00 A.M. SUNNY, CALM, + 65° CEC RLS
STA.	BS	HI	FS		ELEV	SHOTS N ℄ SHOTS S
BM1					1742.20	
	4.62					BM1 IS NAIL IN RR @ INT. OF ROAD (PAINTED RED)
0+00						4.8/30 4.9/23 [illegible]/0 5.1/20' 5.3/30'
0+30						5.9/30 6.3/24 5.9/18' 5.6/12 [illegible]/0 4.3/10 5.8/16 6.6/25 5.6/30
0+50						6.0/30 6.3/25 6.1/14 5.9/13 [illegible]/0 4.6/11 5.7/17 6.3/24' 6.4/30'
1+00						5.0/30 6.8/24 6.3/18' 5.7/12 [illegible]/0 5.5/10 5.8/17 6.7/22' 5.8/30'
TP1			5.14			NAIL IN POWER POLE
	4.16					
1+50						5.3/30 5.9/24 6.7/18' 5.6/12 4.6/0 4.7/11' 5.7/14 6.6/26' 6.3/30
2+00						6.0/30 6.7/27 6.8/20' 5.9/12 4.9/0 5.0/12' 6.2/20' 6.7/28' 6.4/30'
TP2			4.18			ROCK
	5.24					
			4.70			SAME AS ABOVE
	14.02		14.02			
	CK OK					

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Objective 40

Assignment Sheet 6—Draw a Map Using Bearings, Distances, and Coordinates

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy of plotting	______
• Neatness of presentation	______

Basic Skills

Reading Mathematics Critical Thinking

Problem 1: Bearings, distances, and coordinates

Of the six missile complexes in the Southwest area now all abandoned, Complex 2A is located near a north-south county road about 12 miles south of Prairie, Colorado on an old bombing range. The complex consists of three missile silos, associated equipment and propellant terminals, the power house and control center, and the two antenna terminals. The missile silos, the entrance portal, and the antennae are visible on the ground surface. All other facilities, including the interconnecting tunnels, are below ground. The missile silos are 155 feet deep.

Plot the missile complex property boundary from the following bearings and distances. It is suggested the first course commence at a point on an 18" x 24" sheet of paper, 8 inches up and 4 inches to the left of the lower right hand corner, with the long paper dimension arranged vertically. The boundary is to be indicated by long lines broken at intervals by two dots, the standard right-of-way symbol. Coordinates, on an arbitrary base are given for selected property corners for checking purposes. Plot at a scale of one inch = 100 feet.

Boundary:

Point	Bearing	Distance (ft)	Coordinate
A	S 65°27'00" W	621.00	N19,943.63 E43,571.30
B	N 84°53'00"W	442.00	
C	N 38°22'00"W	616.00	
D	N 26°25'01"W	926.00	N21,037.31 E41,771.88 Closing
E	N 31°25'00" E	923.00	
F	East	451.00	
G	S 61°53'00" E	594.00	N21,545.07 E43,227.90 Closing
H	S 04°23'00" E	1000.00	
J	N 85°37'00" E	220.00	
K to A	S 04°23'00" E	623.00	Closing line to Point A

Assignment Sheet 6

Interior Fence:

Point	Bearing	Distance (ft)	Coordinate
AA-BB	N 65°27'00" E	455.00	AA— N 19,889.81 E 42,968.47
BB-CC	N 4°23'00"W	295.00	
CC-DD	S 85°37'00"W	240.00	
DD-EE	N 4°23'00"W	1075.00	
EE-FF	N 61°53'00"W	445.00	
FF-GG	West	285.00	GG—N 21,636.23 E 42,360.84
GG-HH	S 31 °25'00" W	705.00	
HH-JJ	S 24°09'25" E	744.27	
JJ-KK	S 55°35'13" E	165.00	
KK-LL	S 33°30'00" E	410.00	
LL-AA	S 84°53'00" E	300.00	Closing line to Point AA

Coordinates of Selected Structural Features:

Feature	Northing	Easting	Approximate Diameter
Launcher No. 1			
Center of missile silo	21,022.23	42,276.55	40 ft.
Center of equip. term.	21,069.43	42,346.03	40 ft.
Center of prop. term.	20,938.16	42,273.54	37.5 ft.
Launcher No. 2			
Missile silo	21,378.43	42,494.17	40 ft.
Equipment terminal	21,425.63	42,563.65	40 ft.
Propellant terminal	21,294.36	42,491.16	37.5 ft.
Launcher No. 3			
Missile silo	21,206.86	42,737.40	40 ft.
Equipment terminal	21,254.06	42,806.88	40 ft.
Propellant terminal	21,122.79	42,734.39	37.5 ft.
Antennae			
Center of No. 1	20,168.07	42,809.17	28 ft.
Center of No. 2	20,163.26	42,862.95	28 ft.
Center Point of			
Control center	20,680.69	42,562.03	105 ft.
Power house	20,758.97	42,756.89	125 ft.
Portal	20,692.94	42,686.43	35 ft.

Problem 2: Tunnel geometry—stationing

A system of tunnels connects all the facilities shown on the plan assembled as Problem 1. The tunnels are between 43 ft. and 57 ft. below ground surface.

The tunnel stationing commences as 0+00.00 midway on a line joining the centers of the two antennae at coordinates N20,165.67 E42,836.06. Tunnel width between the antennae is 15 ft. This width extends to station 0+50.00 on a line at right angles to the line joining the antennae centers. At this station the width narrows to 10 ft. and the tunnel direction changes. Tunnel geometry from this point northward is given below:

Tunnel Centerline Chaining Station to Station		Bearing	Coordinates at Beginning of Course Northings	Eastings	Tunnel Width in Ft.
0+50.00	7+21.48	N21°53'10'W	20,215.47	42,840.52	10', to 5+69.50; 6 + 54.50 to 7 + 21.48
7+21.48	11+00.43	N6°53'10'W	20,838.55	42.590.21	10',7+21.48 to 8 + 21.95; 8 + 57.28 to 9+31.76; 10+ 11.43 to 11 +00.43
11+00.43	12+92.14	N5°06'50"E	21,214.76	42,544.76	10', 11+00.43 to 11 + 58.93; 11 + 90.93 to 12+43.93; 12+74.93 to 12+92.14
Line joining centers of power house and control center					15'
8+39.63	10+54.04	S83°06'50"W	20,955.85	42,576.05	10', 9+01.62 to 10 + 54.04;
10+54.04	Propellant Terminal No. 1				10', 10+54.04 to 10+67.54; 10+99.54 to P.T. No. 1
10+83.54	Equipment Terminal No. 1	N5°06'50"E	20,932.77	42,333.80	10', 10+99.53 to 11 +51.54; 11 +83.54 to E.T No. 1
11+67.54	Missile Silo #1		21,016.43	42,341.29	M.S. No. 1 Easterly 29 ft.
9+49.44	10+84.04	N83°06'50"E	21,064.86	42,562.88	10', 10+11.43 to 10+84.04
10+84.04	11+78.54	S84°53'10"E	21,081.00	42,706.52	10', 10+84.04to 11 + 62.54
11+78.54	Equipment Terminal No. 3		21,072.58	42,790.64	10', 12+39.54 to 12+91.54; 13+23.54 to E.T No. 3
12+23.54	Propellant Terminal No. 3	21,117.40	42,794.65	10' for 25 ft. east of P.T. No. 3	
13+07.54	Missile Silo No. 3	21,201.07	42,802.14	10' for 29 ft. east of Missile Silo No. 3	
11+74.92	Propellant Terminal No. 2	21,288.97	42,551.42	10' for 25 ft. east of P.T. No. 2	
12+58.98	Missile Silo No. 2	21,379.63	42,558.91	10' for 29 ft. east of Missile Silo No. 2	

Assignment Sheet 6

Tunnel Junctions and Blast Locks are located on the centerlines previously plotted as follows: (15 ft width)

At N20,725.42 E42, 673.38 and southeasterly to the Portal Structure

Tunnel Junction No. 12 at Station 6+70.50 southeasterly for 20 ft. to a hydraulic control room (No details of this.)

Blast Lock No. 1 at Station 9+49.43

Blast Lock No. 2 at Station 9+39.63

Tunnel Junction No. 5 at Station 11+74.92

Tunnel Junction No. 4 at Station 12+58.93

Tunnel Junction No. 7 at Station 13+07.54

Tunnel Junction No. 2 at Station 10+83.54, Launcher No.1

Tunnel Junction No. 1 at Station 11+67.54, Launcher No.1

Tunnel Junction No. 8 at Station 11+78.54, Launcher No.3

Tunnel Junction No. 9 at Station 12+23.54, Launcher No.3

Note: Roads will be added to this map in Unit 9, "Transportation Mapping," Assignment Sheet 2.

717

Objective 41

Assignment Sheet 7—Lay Out the Property Boundary for the MAVCC Topographic Survey Map

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Layout matches instructor's handout	______
• Appropriate labels	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Directions

This assignment will require a civil CAD software program. You will follow the step by step procedure given in your particular software package to create the property boundary for the MAVCC topographic survey map.

1. Obtain from your instructor a copy of the property boundary solution.
2. Locate the property corner points, and build a boundary using those data points from your point file.
3. Label the bearings for each boundary line.

Unit Contents

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6—Fixing a Grade Line 7–37

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3—Calculate Grades 7–49
4—Build a TIN and Make Contours 7–51

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify contours, prepare profiles from a contour map, and calculate grades. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to topographic maps with the correct definitions.
2. Define topographic analysis.
3. List three types of maps that show relief.
4. List uses for topographic maps.
5. Define topographic survey.
6. Distinguish between types of surveys used in topographic mapping.
7. Match field methods for locating topographic details, planimetric features, and contours with their descriptions.
8. List factors affecting the selection of the field method to be used for a topographic survey.
9. Distinguish between controls for topographic surveys.
10. Select true statements concerning characteristics of benchmarks.
11. Arrange in order the steps in laying out a topographic map.
12. Define digital elevation model (DEM).
13. Describe the two basic geometric configurations that are used in the field for collecting DEM data.
14. Define breaklines.
15. Select true statements about the characteristics of a triangulated irregular network (TIN).
16. Complete statements concerning national standards for accuracy on topographic maps.
17. Complete a chart of scale ratios used in the USGS topographic series.
18. Select true statements concerning the selection of contour intervals.

Objective Sheet

19. Complete statements concerning characteristics of contour lines.
20. Complete statements about the characteristics of hachures.
21. Match contour line features with their configurations.
22. Use a polar planimeter to determine acreage. (Assignment Sheet 1)
23. Interpolate contours from a grid survey and prepare profiles from the contour map. (Assignment Sheet 2)
24. Calculate grades. (Assignment Sheet 3)
25. Build a TIN and make contours. (Assignment Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Aerial photograph**—A photograph taken from an airborne vehicle

b. **Backsight**—A survey reading taken on a point of known elevation for the purpose of obtaining the height of the instrument; also called a plus (+) sight

c. **Contour**—An imaginary line on the ground, all points of which are at the same elevation above or below a specified datum surface, usually mean sea level

d. **Contour grading**—Method of design using proposed finished contours; may be used for determination of earthwork

e. **Contour interpolation**—Determination of an intermediate value between field values from some known or assumed rate; estimating of contours

f. **Contour interval**—The vertical distance between the planes of consecutive contour lines, such as 5, 10, 20, 100, or 200

g. **Control point**—Any station in a horizontal or vertical control network that is identified in a data set or photograph and used for correlating the data shown in that data set or photograph

h. **Cross section**—A plane that cuts through at right angles to the horizontal; also refers to a drawing of this plane

i. **Cut and fill**—A road construction term that describes the quantities of earth removed from hillsides and filled into low spots

j. **Datum**—Any numerical or geometrical quantity or set of such quantities that serves as a reference or base for other quantities

Example: Mean sea level serves as a datum for elevation

k. **Depression contour lines**—Indicate an elevation that represents a low place on the ground that has no surface drainage

l. **Foresight**—A survey reading taken on a new point to determine its elevation; also called a minus (–) sight

m. **Grade**—An established elevation of the ground or a road surface; the amount of incline or slope from the horizontal expressed usually in percentages

n. **Gradient**—The rate of grade

o. **Grading plan**—A plan containing original ground contours over which contours of the highway, subdivision, or other embankment or excavation to be completed are superimposed on and connected with the original ground contours at the edge of construction limits

p. **Index contour line**—Every 5th contour line, which is numbered

q. **Intermediate contour lines**—Contour lines that are between index contours

r. **Photogrammetric surveying**—The science of obtaining measurements by means of photographs, usually aerial photographs

s. **Planimeter**—Instrument for measuring plane areas

t. **Profile**—Line representing a longitudinal, vertical section through a roadway or pipeline

u. **Sea level**—Topographic datum line which is the level between high and low tide

v. **Slope**—Degree of rise or fall of a line with reference to the vertical and horizontal planes

w. **Spot elevation**—A point on a map or chart whose height above a specified reference datum is noted, usually by a small "x" and elevation value

x. **Stadia**—Refers to distance and elevation measurements that have been obtained by surveying methods

y. **Stereoplotter**—A piece of equipment that allows the operator to view the stereo model in 3-dimension; from this model topographic and planimetric information can be traced out for future development of a map

Examples: Kelsh, Kern, Ball Plex plotters

z. **Stereoscope**—A pocket size stereoviewer consisting of two magnifying lenses in a metal frame that allows ease in viewing aerial photographs without having to use a stereoplotter

aa. **Stereoscopic model**—The area covered by two overlapping or stereo pair of photos

bb. **Stereovision**—The ability to see three-dimensionally (length, width, and depth at the same time) using two views of a single object from two slightly different positions

cc. **Supplemental contour lines**—Represent half intervals between contour lines

dd. **Topographic map** (as defined by USGS)—A line and symbol representation of natural and selected manmade features of a part of the earth's surface plotted to a definite scale; distinguishing characteristic is the portrayal of the shape and elevation of the terrain by contour lines

ee. **Topography**—Configuration of the land surface; the graphic delineation or portrayal of that configuration in map form, as by contour lines; in oceanography the term is applied to a surface such as the sea bottom or a surface of given characteristics within the water mass

Objective 2

Topographic analysis—The configuration of a surface including its relief and the position of streams, roads, cities, etc.; usually subdivided into relief features, water and drainage features, manmade features, and vegetation

Objective 3

Maps that show relief

a. Hypsometric map—Shows relief by using various conventions and procedures; contours are commonly used

b. Digital elevation model (DEM)—Depicts relief and is computer generated

c. Topographic map—Combines the properties of both planimetric and hyposometric maps

Objective 4

Uses for topographic maps

a. As bases for other maps

Examples: County planning maps, drainage basin maps, geologic maps, land ownership maps, shaded relief maps

b. Planning highways

c. Selecting airport sites

d. Selecting industrial sites

e. Planning subdivisions

f. Routing pipelines and power lines

g. Locating boundary lines for cadastral surveys

h. Planning communication facilities

i. Aiding in agricultural research

j. Planning recreation areas

k. Assessing and managing natural resources

Objective 5

Topographic survey—The method of finding positions of natural and manmade features on the surface of the earth as well as determining the configuration of the terrain; a topographic map can then be developed from data obtained through this type of survey

Objective 6

Types of surveys used in topographic mapping

a. Aerial (photogrammetric) survey—Used for mapping projects covering large areas more than 100 acres

b. Ground (field) survey—Used for large scale maps of small areas less than 160 acres

Note: Often both methods are used in combination. When photogrammetry is used, ground control and field checks are done by a ground survey.

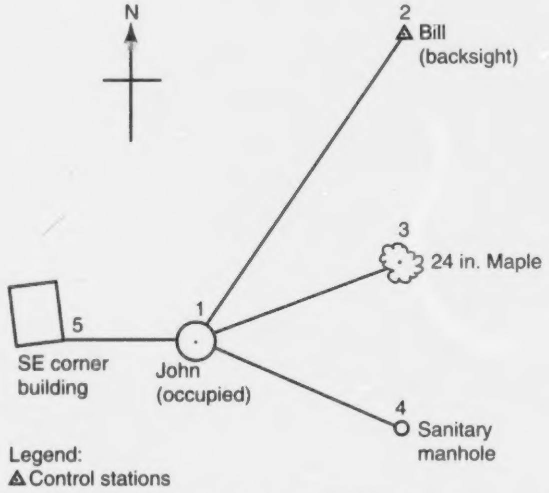
Objective 7

Field methods for locating topographic details, planimetric features, and contours

a. Radiation by total station data collector

- A distance and a horizontal angle or azimuth are measured to each topographic detail point
- Accomplished efficiently if total station is placed on a hill

Figure 1



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b. Radiation by stadia

- Same as radiation by total station except distances are measured by stadia, a way to take measurements with theodolites, transits, plane table, alidades and levels

  Note: Total stationing may be more efficient, but the stadia method is still suitable for many applications.

- Stadia method is based on the principle that in similar triangle, corresponding sides are proportional

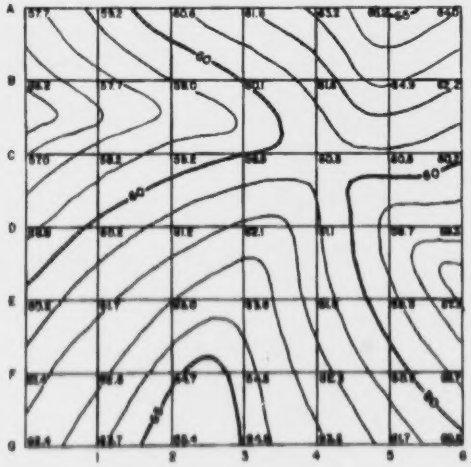
c. Coordinate squares or grid method

- Better suited for locating contours than planimetric features
- Area to be surveyed is staked in squares (10, 20, 50, or 100 ft. on a side)
- Theodolite or transit may be used to lay out control lines at right angles to each other
- Elevations of corners can be obtained by differential or trigonometric leveling

725

- Contours are interpolated between corner elevations

Figure 2


A
B
C
D
E
F
G
1
2
3
4
5
6
60
60
60
60
60

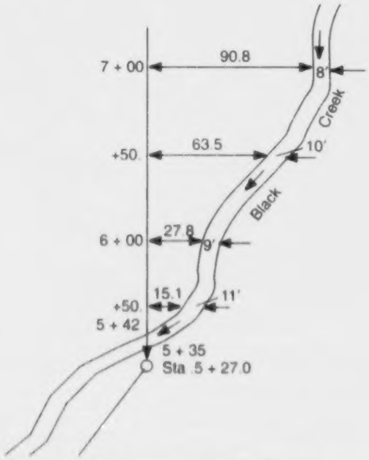
Grid Method for Establishing Contours

From Map Drafting and Related Computations for Plane Surveying: Field Book. Reprinted with permission of the Vocational Curriculum Development and Research Center, Natchitoches, Louisiana.

d. Offsets from a reference

- Most often used for mapping long linear areas such as route surveys
- Planimetric details, such as trees, utilities, fences, buildings, etc., are located by offsets from a center line
- Elevations for contouring are determined by offsets using the technique of cross sectioning

Figure 3


7 + 00
90.8
8'
Creek
+50
63.5
10'
Black
6 + 00
27.8
9'
+50
15.1
11'
5 + 42
5 + 35
Sta 5 + 27.0

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e. Plane table method

- Same as graphic radiation by stadia, only the equipment and procedure are different
- One of the oldest methods of surveying and seldom used today
- Compiled directly in the field on a drawing board mounted on a tripod with an alidade mounted on the board

f. Topographic detail with a portable global positioning system (GPS)

- A new satellite-based surveying procedure
- GPS can compute in real time the coordinate locations of where the receiver is placed
- Files can be directly downloaded to a computer for further processing
- An automatic topographic map can be drafted from this data

Objective 8

Factors affecting the selection of the field method to be used for a topographic survey

a. Purpose of survey

b. Map use (accuracy required)

c. Map scale

d. Contour interval

e. Size and type of area involved

f. Cost

g. Equipment and time available

h. Experience of survey personnel

Note: Selection of a field method is often governed by the type of equipment available to the surveyor.

Objective 9

Controls for topographic surveys

a. Horizontal control

- Provided by two or more points on the ground, precisely fixed in position by distance and direction

- Control established by:
  - — Traversing (small land areas)
  - — Triangulation (large land areas)
  - — Trilateration (large land areas)
  - — Inertial and satellite methods (technical advances, such as GPS, for establishing control for large land masses)

b. Vertical control

- A vertical control net is established by lines of levels starting from and closing on benchmarks.
- Elevations are established for all traverse hubs.
- Topographic details are usually built upon a framework of traverse hubs whose positions and elevations have been established.

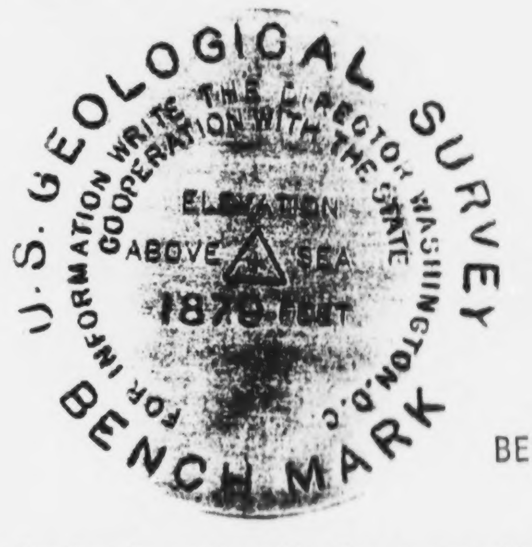
Objective 10

Characteristics of benchmarks (BM)

a. A benchmark is a vertical reference point, whose elevation above and below an adopted elevation is known.

b. USGS benchmark is a brass disk set in concrete and tied to mean sea level.

Figure 4


U.S. GEOLOGICAL SURVEY
BENCH MARK
FOR INFORMATION WRITE THE DIRECTOR WASHINGTON, D.C.
COOPERATION WITH THE STATE
ELEVATION
ABOVE SEA
1879 FEET

BEST COPY AVAILABLE

c. Benchmarks may be set in other permanent-type markers.

d. Elevations are measured at the top of the marker.

e. On maps they are shown as black crosses; corresponding elevation usually labeled with the BM annotation.

Information Sheet

Objective 11

Steps in laying out a topographic map

a. Run an accurate closed traverse within the area to be mapped.

Note: Even when an open traverse is run, a closure check is done by connecting the two end stations.

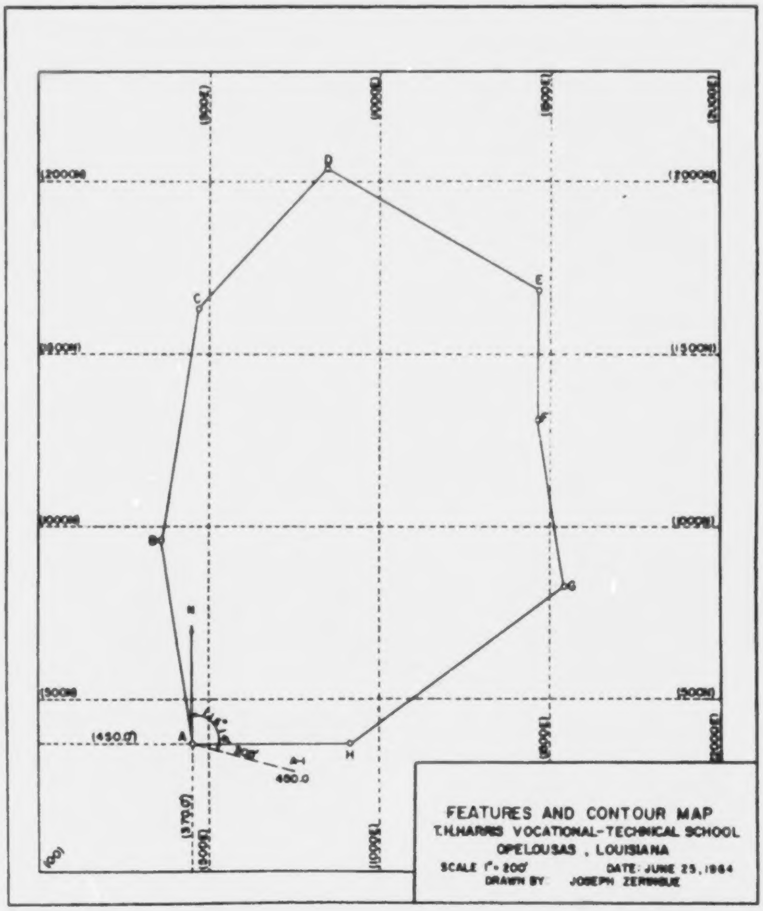
b. Calculate latitudes and departures, adjust traverse, and calculate coordinates.

c. Using the coordinates, plot the traverse.

Note: This establishes horizontal control.

Example:

Figure 5



(500E)
(1000E)
(1500E)
(2000E)
(2000N)
(1500N)
(1000N)
(500N)
A
B
C
D
E
F
G
H
(450.0')
(370.0')
400.0
FEATURES AND CONTOUR MAP
T.H.HARRIS VOCATIONAL-TECHNICAL SCHOOL
OPELOUSAS, LOUISIANA
SCALE 1" = 200'
DATE: JUNE 25, 1964
DRAWN BY JOSEPH ZERINGUE

d. From the points located by the horizontal control traverse, make a survey (by hand or computer) locating all the details of features to be shown.

e. Establish contours from vertical control.

Objective 12

Digital elevation model (DEM)—Three dimensional array which provides a digital representation of continuous relief of an area of land. Data collected for this type of automated contouring system are in an array of points. Horizontal positions are x and y coordinates with their elevations represented as z coordinates.

Note: This is sometimes referred to as a digital terrain model (DTM).

Objective 13

Basic geometric configurations that are used in the field for collecting DEM data

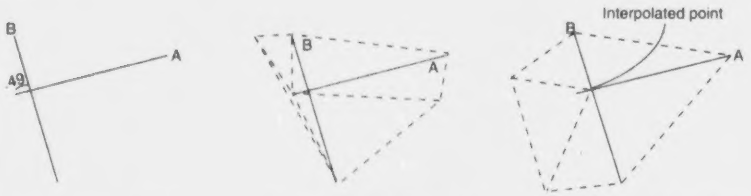
a. Grid method—Elevations are determined by points which conform to a regular square or rectangular grid; a disadvantage of this method is points are only picked up at grid intersections

b. Irregular method—Controlling point method which involves determining the elevations of all high and low points and points where slope changes

Objective 14

Breaklines (discontinuity lines)—Linear topographic features which have uniform slopes, such as streams, lake shores, roads, railroads, ditches, ridge lines; these breaklines become sides of the triangle in the TIN model and elevations are then interpolated along them

Figure 6



Crossing Breakline

TIN made with Breakline Tolerance set to .0001

TIN made with Breakline Tolerance set to .5

Courtesy of Eagle Point Software

Objective 15

Characteristics of a triangulated irregular network (TIN) when used for an automated contouring network

a. TIN models are created from a multiple array of surveyed points.

b. A TIN model is constructed by connecting points in the array to create a network of adjoining triangles.

c. Most common TIN is a network of equilateral triangles.

d. All triangle sides in a TIN have a constant slope.

e. The surface area of any triangle in a TIN is a plane.

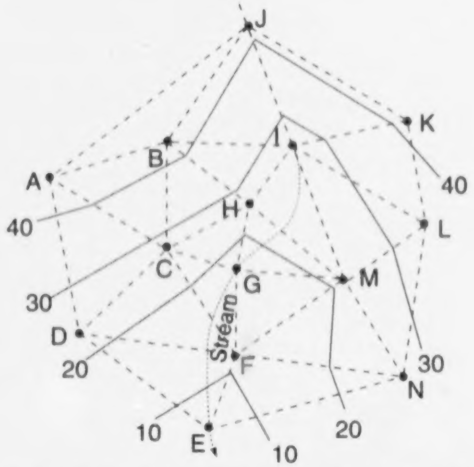
f. Elevations of contour crossings are interpolated along the triangle edge.

g. Contours change direction only at triangle boundaries.

h. TIN created for automated contouring must have field points selected carefully, breaklines identified and data properly inputted in order to create a good output.

Note: Generally, this requires more control points.

Figure 7



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Objective 16

National standards for accuracy on topographic maps

Note: For more details, refer to Student Supplement 1.

a. Horizontal accuracy—Requires no more than 10 percent of well-defined map points tested to be more than 1/50 inch (0.5mm) out of correct position at publication scales of 1:20,000 or smaller

b. Vertical accuracy—Requires that no more than 10 percent of the elevations of test points interpolated from contours be in error more than half the contour interval

Objective 17

Scales for topographic map series—USGS

Figure 8

Series	Scale	One Inch Represents	Standard Quadrangle Size (latitude & longitude)	Quadrangle Area (square miles)
7.5-minute	1:24,000[1]	2,000 feet	7.5 x 7.5 min.	49 to 71
15-minute	1:62,500[2]	about 1 mile	15 x 15 min.	197 to 282
Intermediate-scale quadrangle	1:100,000	over 1.5 miles	30 min. x 1°	1,145 to 2,167
U.S. 1:250,000[3]	1:250,000	about 4 miles	1° x 2°	4,580 to 8,669
International Map of the World	1:1,000,000	about 16 miles	4° x 6°	73,734 to 102,759

[1] For Alaska, the scale is 1:25,000 and for Puerto Rico, 1:20,000

[2] For Alaska, the scale is 1:63,360 (1 inch represents 1 mile) and the quadrangle size is 15 x 20 to 36 minutes.

[3] Maps of Alaska and Hawaii vary from these standards.

Objective 18

Selection of contour intervals

a. Standard of accuracy required affects the selection of a contour interval.

Example: National standards can interpolate a map within 1/2 contour interval. If accuracy required is 1 foot, then a 2 foot maximum interval is necessary.

b. Terrain type regulates the contour interval

- Rugged terrain requires a larger contour interval
- Flat ground uses a small contour interval to show the surface adequately

c. If map scale is reduced, the contour interval is increased.

d. 5, 10, 20, 100, and 200 feet are the intervals most commonly used.

e. USGS commonly uses 40 foot contour intervals.

f. Defense Mapping Service (DMS) commonly uses 50 foot contour intervals.

g. Contour interval should not vary on any one map.

Note: Some maps that represent very flat terrain may employ 1/2 contours. These are usually shown as dashed.

h. Common rule on contour intervals is not to show more than 10 contours per linear inch.

Objective 19

Characteristics of contour lines

a. A contour is a line, all points of which lie at equal elevations.

b. Every contour closes upon itself either within or without the limits of the map; in the latter case it is drawn to the edge of the map.

c. A contour line closing within the limits of the map either indicates a summit or a depression. If the depression does not enclose a body of water, it should be numbered or hachured to indicate its elevation.

d. Contours never cross each other, except in the case of an overhanging cliff or a cave, and then they must cross twice. Such cases seldom occur, but if they do, the lower contour should be dotted.

e. On uniform slopes, contours are evenly spaced.

f. On a plane surface, contours are straight lines, parallel to each other.

g. Contour lines are perpendicular to the direction of maximum slope.

h. The spacing between contour lines indicates steepness of slope, i.e. close spacing indicates steep slope.

i. The sharpest bends in contours occur at their intersection with ridge and valley lines, which they cross at right angles.

j. A single contour cannot intervene between two other contours having the same elevation either on a summit or in a valley.

Example: The maximum ridge and minimum valley contours must occur in pairs if they do not close within the limits of the map.

k. One contour cannot be superimposed upon another except where they indicate a vertical cliff.

l. Contours bend toward the upgrade when crossing a valley or depression, and toward the downgrade when crossing a ridge line, creating a v-shaped contour.

m. Contours crossing a railroad laid to an even grade will be spaced at equal intervals.

n. Contour lines crossing a stream point upstream and form V's; they point down the ridge and form U's when crossing a ridge crest.

o. Contour lines cannot run into the shore of a lake or other still body of water since the water surface is at the same level at all points.

p. It is customary to make every fifth contour line (index contour) heavier than the rest. The line is broken at some convenient place and the number representing the elevation is inserted. When contour lines are far apart, each one may be numbered.

q. On a summit or low point the last contour line is labeled and the elevation within the contour is given.

r. Existing contours are dashed; proposed contours are solid.

Objective 20

Characteristics of hachures

a. A hachure is a series of short lines drawn in the direction of the slope.

b. On a steep slope, the hachure lines are heavy and spaced close together.

c. Hachure lines do not give actual elevations of the ground.

d. Hachure lines give a general impression of the ground configuration.

e. Hachures are used on topographic maps for features too small to show by contour lines (i.e. mine dumps, or small banks).

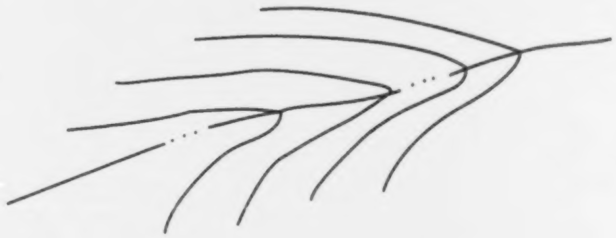
f. Contour depressions are shown by hachure symbols shown as short ticks at right angles to the contour, pointing towards the center of the depression.

Objective 21

Typical contour line configurations

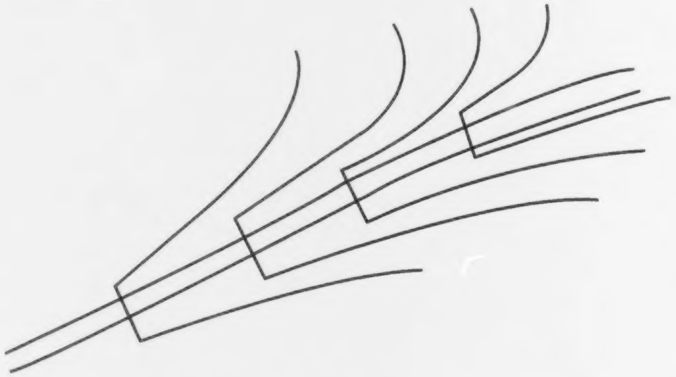
a. Stream

Figure 9



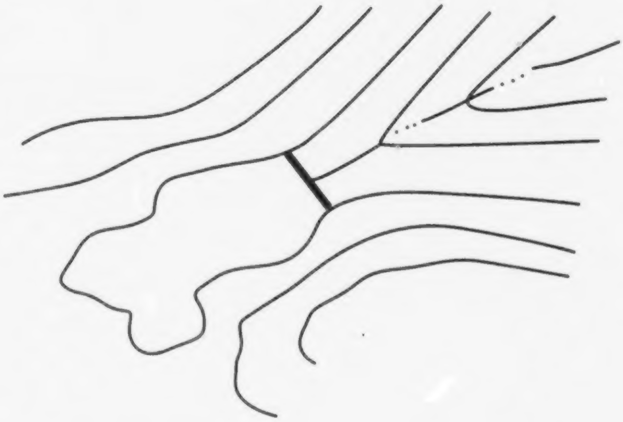
b. Embankment

Figure 10



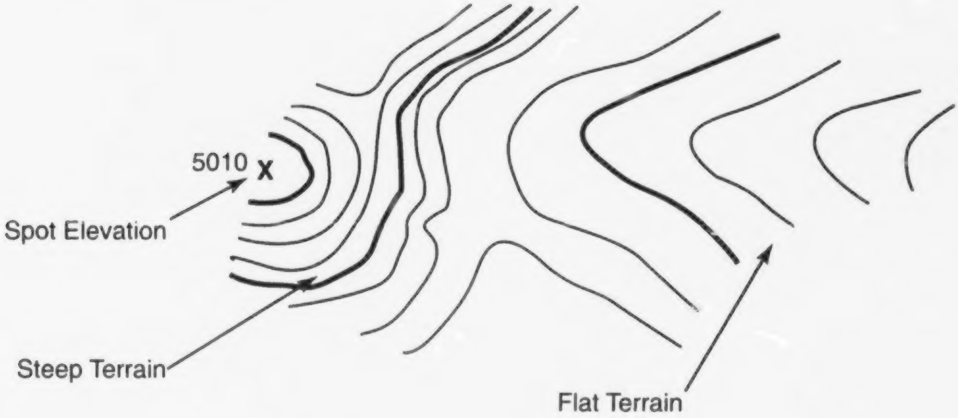
c. Dam

Figure 11



d. Steep and flat terrain

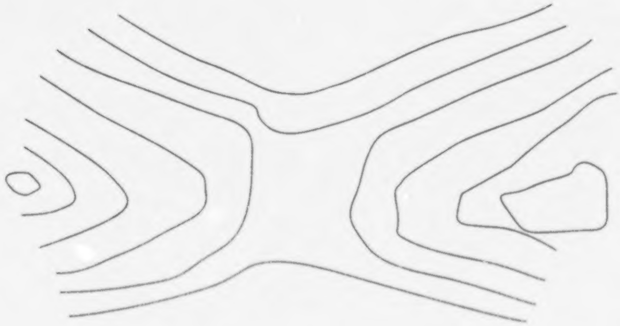
Figure 12


5010 X
Spot Elevation
Steep Terrain
Flat Terrain

735

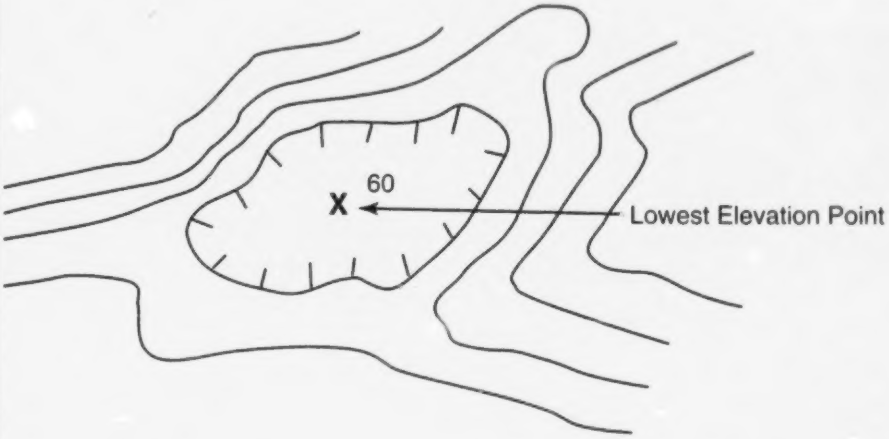
e. Saddle

Figure 13



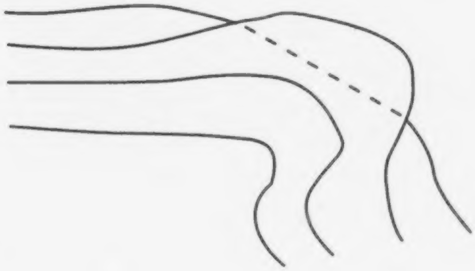
f. Depression contour

Figure 14


60
X
Lowest Elevation Point

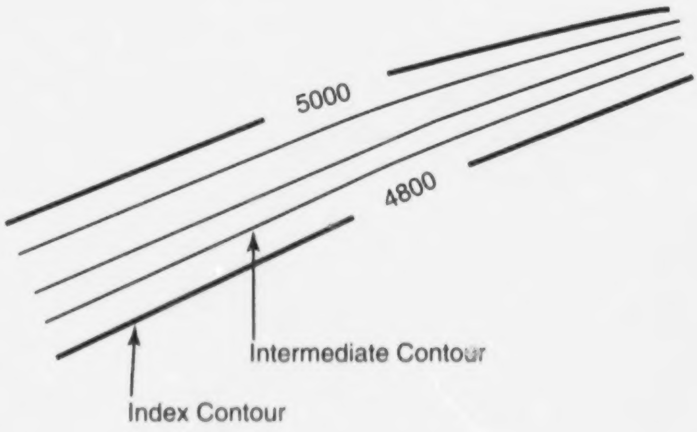
g. Overhang or cliff

Figure 15



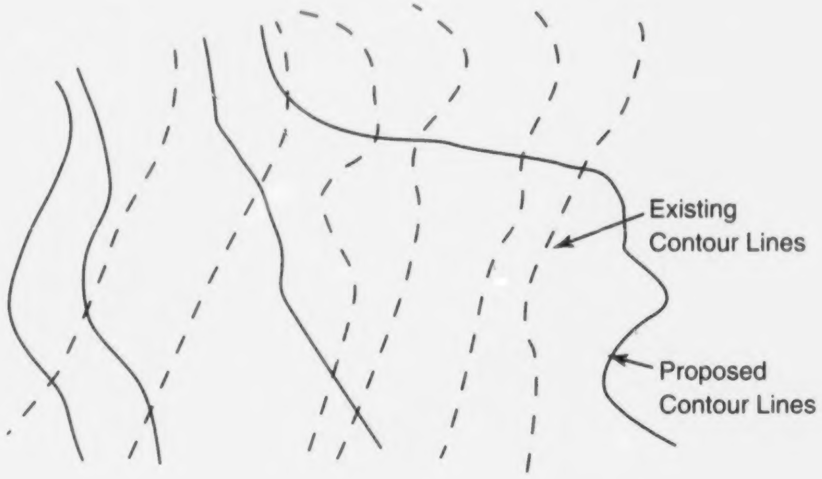
h. Index and intermediate contours

Figure 16


5000
4800
Intermediate Contour
Index Contour

i. Original and finished contours

Figure 17


Existing
Contour Lines
Proposed
Contour Lines

737

Student Supplement 1—United States National Map Accuracy Standards

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. **Horizontal accuracy**. For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.

2. **Vertical accuracy**, as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

3. **The accuracy of any map may be tested** by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.

4. **Published maps meeting these accuracy requirements** shall note this fact on their legends, as follows: "This map complies with National Map Accuracy Standards."

5. **Published maps whose errors exceed those aforestated** shall omit from their legends all mention of standard accuracy.

6. **When a published map is a considerable enlargement** of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000 scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."

7. **To facilitate ready interchange and use of basic information for map construction** among all Federal mapmaking agencies, manuscript maps and published maps, wherever economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3 3/4 minutes in size.

Issued June 10, 1941
Revised April 26, 1943
Revised June 17, 1947

U.S. BUREAU OF THE BUDGET

Student Supplement 2—Methods Used to Calculate Area From a Topographic Map

Planimeter Method

Standardization

Standardize the planimeter for a known area on the same paper medium as the map. With the planimeter tracing point, freehand the boundary of the known area in a clockwise direction.

Calculations

Divide the known area by the average reading. Each value of the planimeter counter is now equal to a known area.

Unknown Area

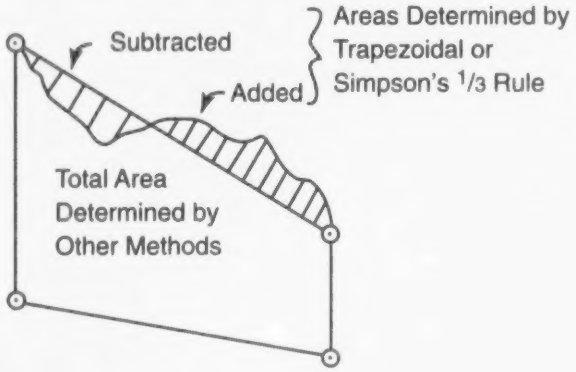
Trace the unknown area in a clockwise direction. Repeat at least 2 times and average by the area value for the total area.

Note: This procedure is covered in more detail in Unit 12, Job Sheet 1.

Irregular Boundaries Methods

Note: The area of a parcel of land bound by an irregular boundary, such as a shore or a river, cannot be determined uniquely like the area of a rectangle, trapezoid, etc. Several *approximate methods* are possible (trapezoidal, Durand's, Simpson's rule, etc.) and all are based on the concept of subdividing the total area into n-strips. The boundary then approximates a straight line (trapezoidal rule) or a known curve (parabola = Simpson's rule), and the total area then becomes the sum of the individual, calculatable areas. The greater the number of strips used, the more accurate the area and the easier it will be to draw the boundary on the plat.

Figure 1

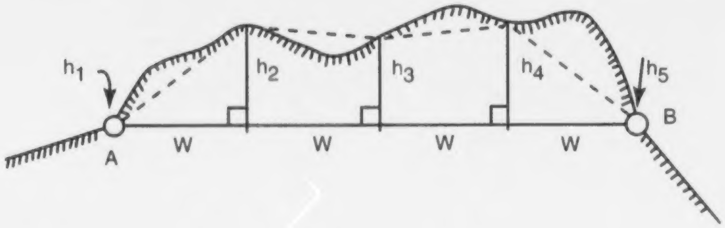

Subtracted
Added
Areas Determined by Trapezoidal or Simpson's $^{1}/_{3}$ Rule
Total Area Determined by Other Methods

Student Supplement 2

Trapezoidal Rule

1. Given an irregular boundary, divide the baseline (AB) into any desired, but regular intervals (w). From the baseline establish perpendicular offsets (h, h, etc.) to the boundary.

   Figure 2



2. The area of a trapezoid is:

$$A = w\left(\frac{h_a + h_b}{2}\right)$$

3. The total area of several adjacent trapezoids is:

$$A_T = w\left(\frac{h_1 + h_2}{2}\right) + w\left(\frac{h_2 + h_3}{2}\right) + w\left(\frac{h_3 + h_4}{2}\right) + \ldots + w\left(\frac{h_n - 1 + h_n}{2}\right)$$

4. Combining the above mathematically gives the equation for the trapezoidal rule.

$$A_T = w\left(\frac{h_1 + h_n}{2} + h_2 + h_3 + \ldots + h_{n-1}\right)$$

WHERE: A_T = total area
w = interval spacing (constant)
h = perpendicular offset distances

Note: Some offsets may be zero (0).

EXAMPLE: Given:

w = 20.00 ft	h_3 = 14.73 ft
h_1 = 0.00 ft	h_4 = 15.91 ft
h_2 = 16.08 ft	h_5 = 0.00 ft

$$A_T = 20.00\text{ft}\left(\frac{0.00\text{ft} + 0.00\text{ft}}{2} + 16.08\text{ft} + 14.73\text{ft} + 15.91\text{ft}\right)$$

$= 934.4\text{ft}^2$ = Answer

Simpson's Rule (Simpson's 1/3 Rule)

Simpson's rule is similar to the trapezoidal rule, but it assumes that the curve through each successive 3 points is a portion of a parabola. It normally gives a better fit (area) than the trapezoidal rule.

1. Given an irregular boundary, divide the baseline (AB) into an *even number* and *regular* intervals (w). From the baseline establish perpendicular offset (h_1, h_2, etc.) to the boundary.
2. Label all offsets, by starting with h at the beginning of the baseline.
3. Equation: Simpson's rule

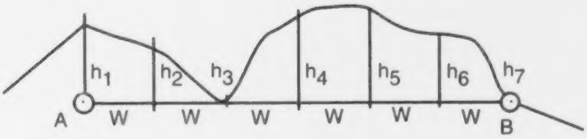
$$A_T = \frac{w}{3}\left[(h_1 + h_n) + 4\,\Sigma h_{even} + 2\,\Sigma h_{odd} \right]$$

WHERE: A_T = total area
w = interval spacing (constant)
h = perpendicular offset distance

Note: Some offsets may be zero (0).

Example:

Figure 3



Given: w = 11.59 ft
h_1 = 10.52 ft (FIRST)
h_2 = 9.03 ft
h_3 = 0.00 ft
h_4 = 13.74 ft
h_5 = 13.86 ft
h_6 = 7.52 ft
h_7 = 0.00 ft (LAST)

Solution:

$$A_T = \frac{w}{3}\left[(h_1 + h_n) + 4 \bullet h_{even} + 2 \bullet h_{odd} \right]$$

$$A_T = \frac{11.59\text{ft}}{3}\,(10.52\text{ft} + 0.00\text{ft}) +$$

$$4\,(9.03\text{ft} + 13.74\text{ft} + 7.52\text{ft}) + 2\,(0.00\text{ft} + 13.86\text{ft})$$

$= 615.82\ \text{ft}^2 = 616\ \text{ft}^2$ (to 3 sig. fig.) = **Answer**

Computer

Using the pline command, follow the procedure as determined by the computer software to calculate the area.

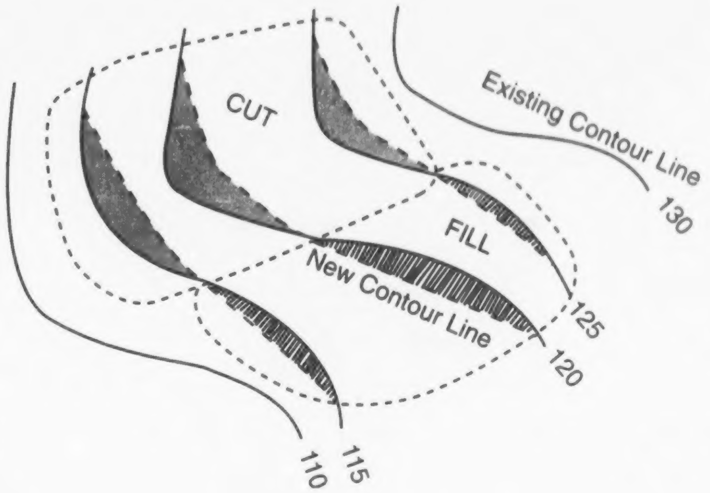
Student Supplement 3—Methods Used to Calculate Cut and Fill

Method 1: Contour Area Method

Note: Grading plan must be in place. This method is adequate for general quantity estimates.

1. Make an earthwork diagram on the grading plan.
2. Draw boundary lines of no-cut, no fill.
3. Bring out new contours where they differ from the old by interconnecting the points where the new contours rejoin the old ones.
4. Shade the areas between old and new contours at each level, using one color for cut and another for fill.

   Figure 1



5. Measure the shaded areas with a planimeter.
6. Approximate the volume of the cut and fill by multiplying the contour interval by the sum of shaded areas.

   Example: In Figure 1, the contour interval is 5 feet.

   Total volume (V) in cubic feet is:

   $V = 5 (A_1 + A_2 + A_3)$

Student Supplement 3

Method 2: Steps to Calculate the Area of a Cross Section

1. Determine vertical and horizontal scale.
2. Using a planimeter, measure the number of square inches in the area to be measured.
3. Using the following formula, determine the number of square feet in the area of the cross section.

Example: Scale = 1″ = 10 ft. horizontal
1″ = 1 ft. vertical

Planimeter reads: 25.25 in^2

Scale =

$$\frac{10\text{ ft.}}{1\text{ in. horiz.}} \times \frac{1\text{ ft.}}{1\text{ in. vert.}} = \frac{10\text{ ft.}^2}{\text{in}^2}$$

$$\frac{10\text{ ft.}^2}{\text{in}^2} \times 25.25\text{ in}^2 = 252.5\text{ ft.}^2$$

Student Supplement 4—Methods for Developing a Profile

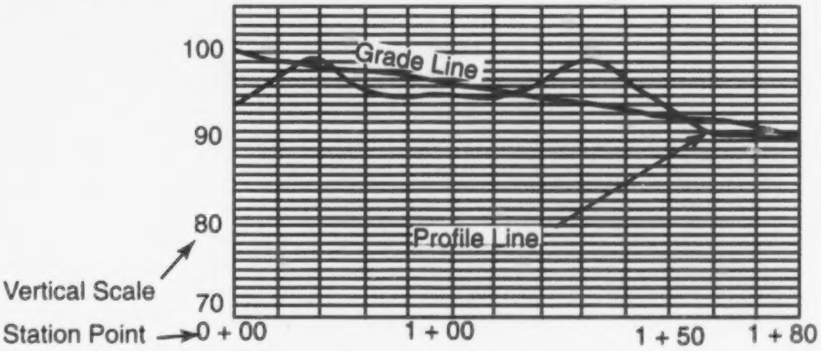
Method 1: Plot a Profile From Field Notes

STA	+	HI	–	ROD	ELEV
BM#5	5.02	62.27			57.25
TP#1	0.27	55.28	7.26		55.01
0+0				3.34	51.94
1+0				4.42	50.86
TP#2	2.66	48.52	9.42		45.86
2+0				9.75	38.77
BM#6			7.17		41.35
Σ	7.95		23.85		
Check:			57.25		
			+ 7.95		
			65.20		
			– 23.85		
			41.35	Check OK	

1. Use profile paper for layout.
2. Establish appropriate horizontal and vertical scales.
3. Given a set of field notes, always check calculations. Add the initial elevation and the total (Σ) of backsights, then subtract the total (Σ) foresights, and this should equal the final elevation.

4. Using the information given in the level notes for the elevation for each station (point), begin to plot elevation points starting at station 0+00.

Figure 1



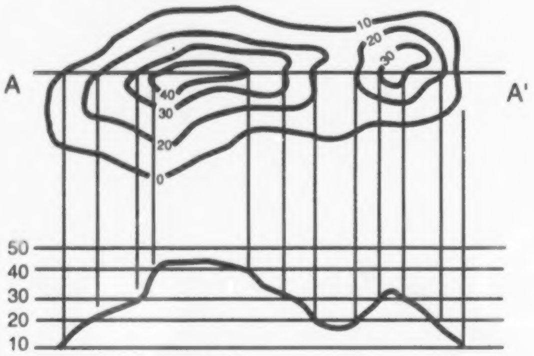
5. Once all elevations are plotted, the points should be connected with a smooth line.

Method 2: Developing a Profile From a Contour Map

Note: This is the least common method of plotting profile. The preferred method is from profile field notes.

1. Contour map is placed above the profile grid and is then considered the plan view.
2. The location of the cross section cutting plane line is marked on the contour drawing.
3. The extremes of elevations are determined from the cutting plane line on the contour map.

Figure 2



Profile A-A'

4. Appropriate vertical scale is selected and is labeled on the profile paper with the elevation required.

   Note: It is customary in civil engineering to draw the profile to an exaggerated vertical scale. Horizontal scale is already determined by the contour drawing.

5. The point of intersection of the cutting plane line and the contour line is projected to the profile.

   Note: The elevation of the intersecting contour should correspond to the same profile elevation.

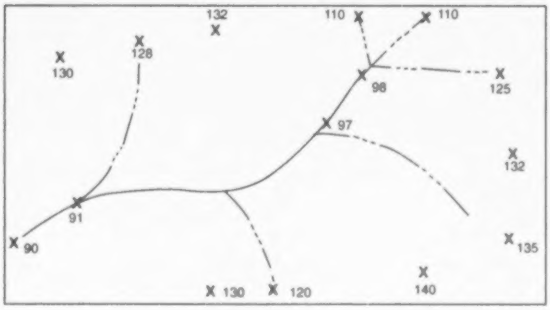
6. The projected points are connected with a smooth continuous line and any elevations or features are labeled.

Student Supplement 5—Manual Methods for Plotting Contour Lines

Random Pattern Plotting From Stadia Notes

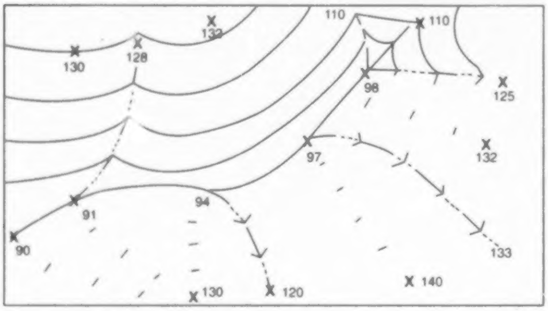
1. Given: A series of random points (elevations) located in critical points such as ridges, summits, stream junctions, guides, etc. This theory of contouring works on the assumption that the slope between two points is constant.

   Figure 1


132
110
110
130
128
98
125
97
132
91
90
135
130
120
140

2. Along the main stream line, interpolate the elevations of all stream junctions not given.

   Figure 2

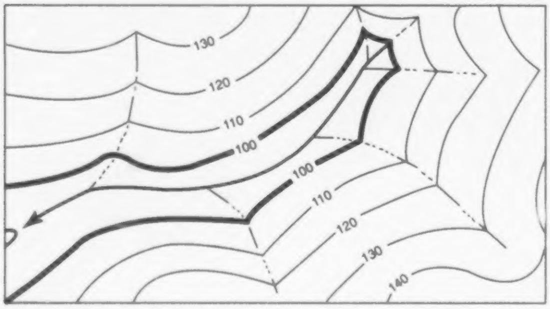

130
128
132
110
110
98
125
97
132
94
91
90
133
130
120
140

3. Using these tick marks along the streams, it is possible to interpolate the contour intervals. The contours crossing at the stream "V" with the "V" pointing upstream.

4. Next, interpolate the contour intervals on the hills between the stream beds using the placement of contour intervals on the streams as a guide.

5. Finalize the contours, completing one contour at a time. Make sure the subsequent contour conforms to the previous contour.

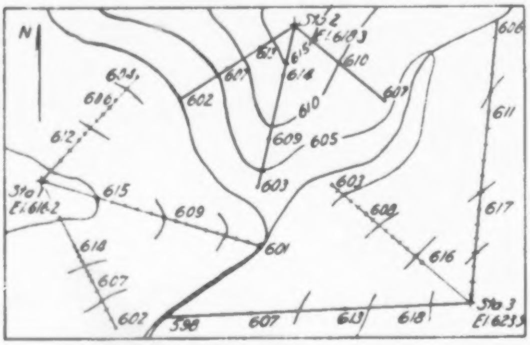
Figure 3


130
120
110
100
100
110
120
130
140

Radial Pattern Contouring

1. Given from field notes a radial pattern of elevation points from a traverse point.

Figure 4


N
Sta 2
El 618.3
606
615
614
610
602
609
610
605
603
611
Sta 1
El 616.2
612
615
609
601
603
608
617
616
614
607
602
598
607
613
618
Sta 3
El 623.5

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2. Assuming the slope between elevation points is even, the distance between points can be divided into a number of spaces equal to the difference in elevation between points.

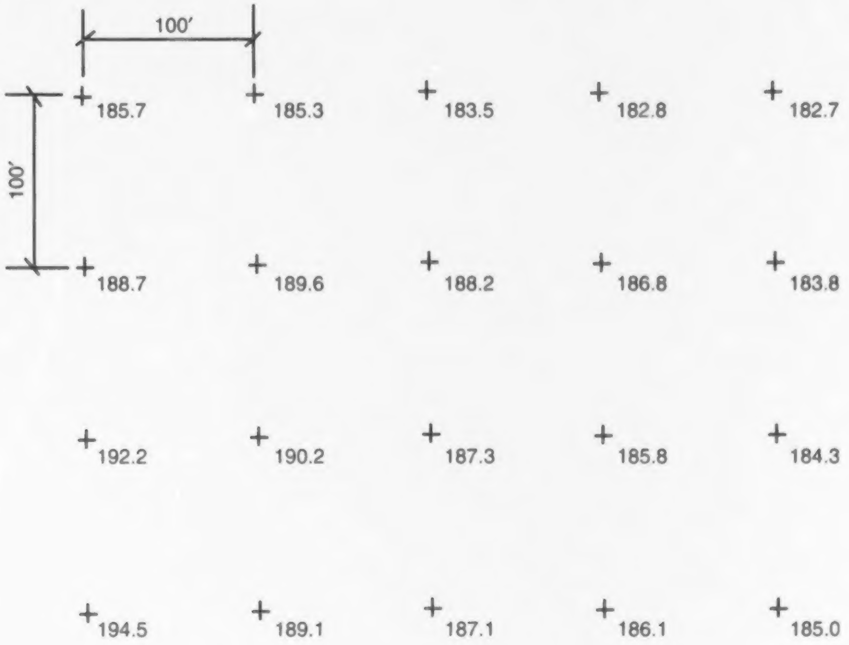
3. Then the tick marks which fit the contour interval are connected with a smooth conforming line.

Note: It is here where contour interpolation takes on artistic form. When in doubt, always make contour lines parallel to each other and evenly spaced between control points.

Contouring From a Grid Pattern

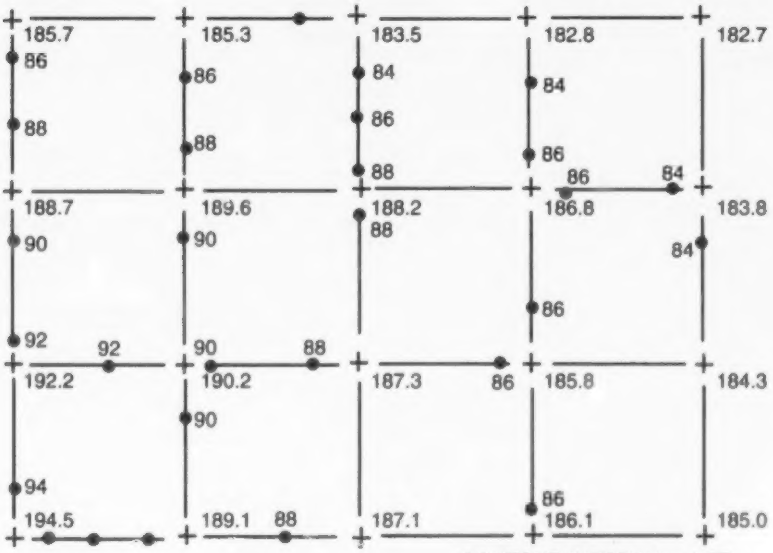
1. Given from field notes a series of elevations that lay out a grid pattern.
2. Establish the grid points with the appropriate scale. Label each grid point with its assigned elevation.

Figure 5


100′
100′
185.7
185.3
183.5
182.8
182.7
188.7
189.6
188.2
186.8
183.8
192.2
190.2
187.3
185.8
184.3
194.5
189.1
187.1
186.1
185.0

3. Determine how many contour intervals fall between each grid point. Use a scale or dividers to locate each point of interval between grid points.

Figure 6

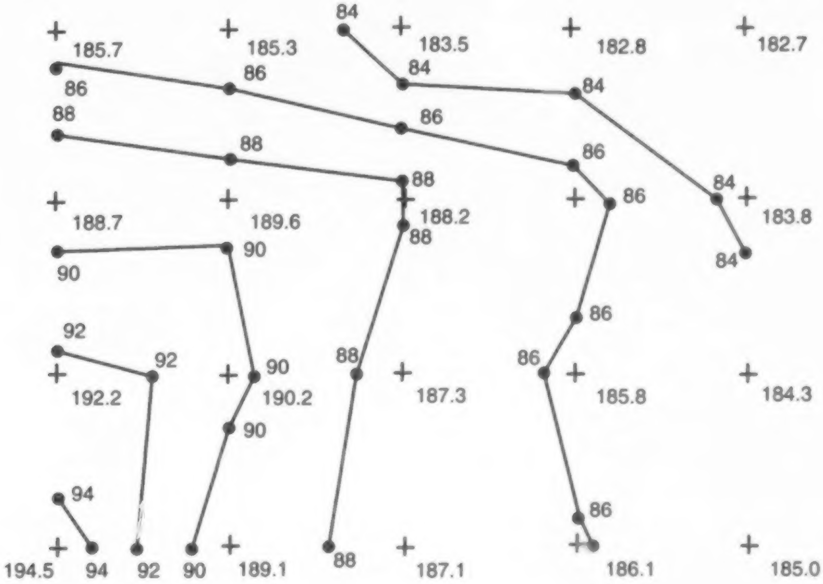

185.7
86
88
185.3
86
88
183.5
84
86
88
182.8
84
86
182.7
188.7
90
92
189.6
90
188.2
88
186.8
86
84
183.8
84
86
92
90
88
192.2
190.2
90
187.3
86
185.8
184.3
94
194.5
189.1
88
187.1
86
186.1
185.0

CONTOUR INTERVAL = 2 FT

4. Carefully connect lines of the same elevation.

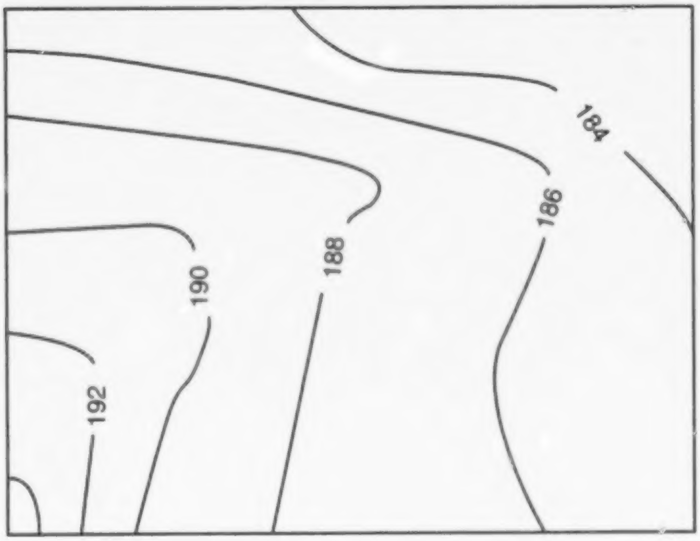
Note: Lines should not cross and if a question occurs, a site visit may be necessary to clarify the lay of the land.

Figure 7


84
185.7
185.3
183.5
182.8
182.7
86
86
84
84
88
86
88
86
88
84
188.7
189.6
188.2
88
86
183.8
84
90
90
86
92
92
90
88
86
192.2
190.2
187.3
185.8
184.3
90
94
86
194.5
94
92
90
189.1
88
187.1
186.1
185.0

5. Smooth out contour lines to follow evenly with each other. Assign labeling to index contours.

Figure 8



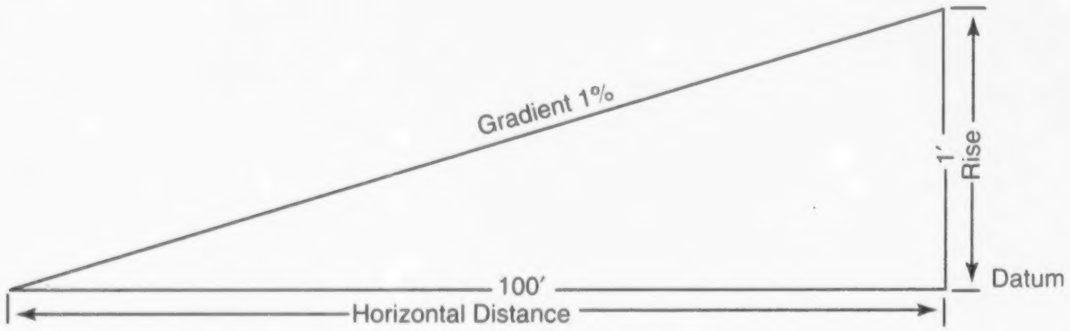
750

Student Supplement 6—Fixing a Grade Line

1. Ground profile is used as the basis of study to fix the grade location.
2. Factors that control grade:
   - Location of stream crossings
   - Beginning and ending points
   - Routes through towns and villages
   - Maximum rates of grade for the type of traffic using the highway or railway
3. Grade is selected and fitted to the ground so as to eliminate excessive cut and fill.
4. Balance site. The amount of dirt removed from the cuts should closely equal the amount required to fill the low areas to avoid expensive hauling of fill dirt.
5. The gradient is found by dividing the amount of rise by the horizontal distance.
6. The percent of grade is found by multiplying the gradient by 100.

   Example: If a road uses one foot vertically in a horizontal distance of 100 feet, it has a 1% grade.
7. Example of mathematical relationships

   Figure 1



$$\text{Percent of grade} = \frac{\text{Rise}}{\text{Distance}} \times 100$$

8. Depending on the type of project, the grade line will pertain to different slopes.
    - Highways, roads, and bridges—Grade is the finished vertical cross section at center line.
    - Other structures—Grade line represents subgrade.
    - Railroads—Grade line represents the location of the base rail.
9. Grade when calculating cut and fill
    - Grade higher than elevation in the profile; a notation to fill is shown.

      Example: F 5.67′
    - Grade below the profile elevation, a cut notation is used.

      Example: C 2.87′

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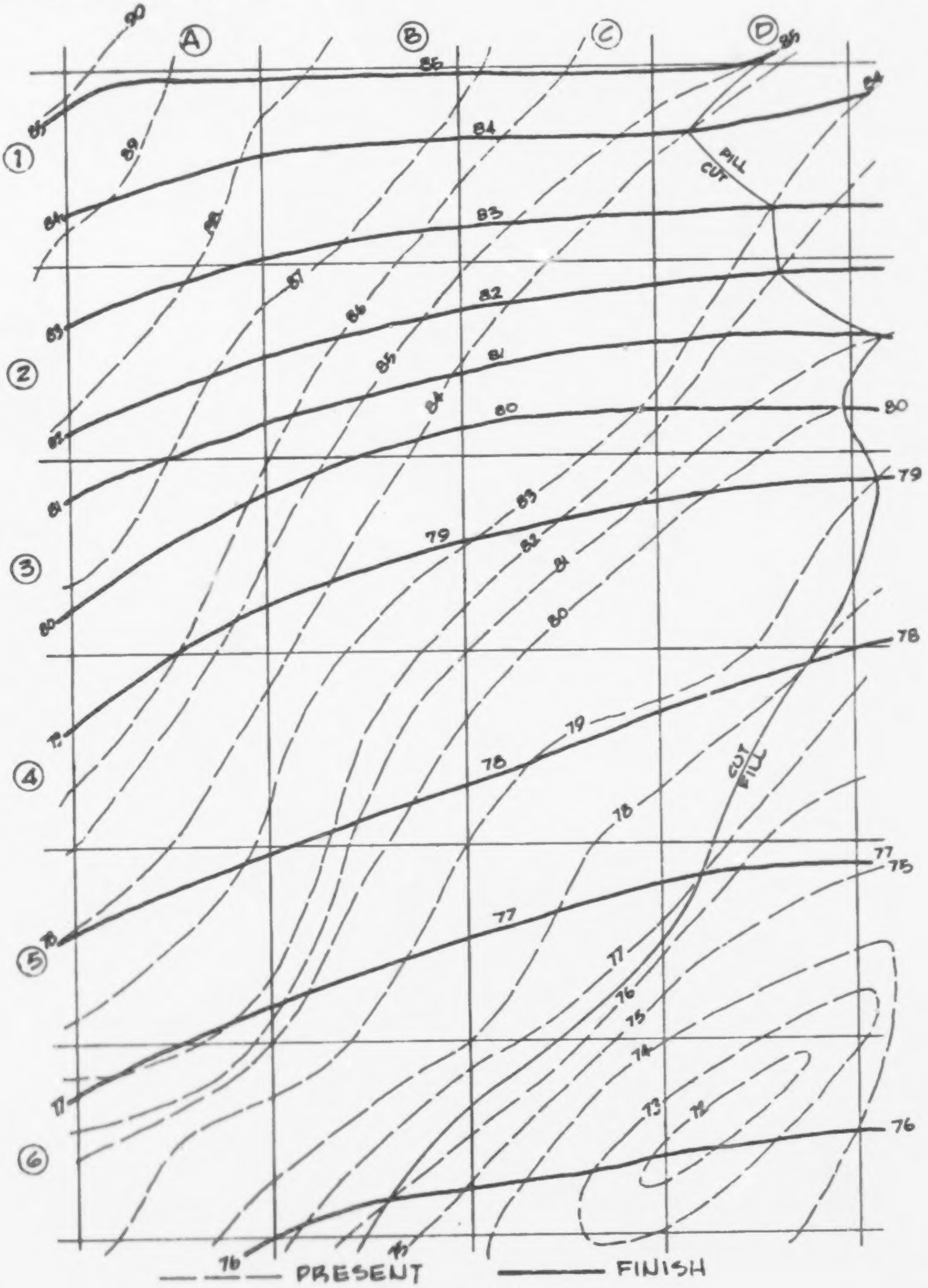
Example of a Grading Plan


A
B
C
D
1
2
3
4
5
6
90
89
88
87
86
85
84
83
82
81
80
79
78
77
76
75
74
73
72
FILL
CUT
CUT
FILL
PRESENT
FINISH

Scale 1" = 40'

Objective 22

Assignment Sheet 1—Use a Polar Planimeter to Determine Acreage

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Answers are correct	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics Critical Thinking

Note: Complete this assignment after having your instructor demonstrate how to use a polar planimeter.

Materials list

- Polar planimeter
- Map area to be measured
- Paper and pencil for recording results

Directions

Follow the step-by-step procedure given below for calculating acreage using a polar planimeter. Calculate the average acreage of the following topographic areas.

Procedure

1. Set planimeter in place. Position pole outside the area to be measured.

   Note: If area is too large for one swing around it, establish one or more division lines. Planimeter each part and add them together. Place arms to form as near a 90° angle as possible when tracing area. When arm is extended more the 90°, it loses accuracy.

2. Zero up the dials or readout at zero.

   Note: Refer to the manufacturer's manual for instructions on your planimeter.

3. Trace around area to be measured in a clockwise direction.

4. Record the number on the dial

   - On a fixed arm planimeter, if length on tracer arm (AT) is set without the ability to adjust, it is usually set at a ratio of 1:10.

     Example: 1″ x 1″ square = 1.00 revolutions
     Therefore, area traced = Number of revolutions x 10

Assignment Sheet 1

- For planimeter with adjustable arm, allow for different settings.

  Example: 1″ = 20 up to 1 = 200′
  Set for a linear scale means 1 square inch = 400 square feet

5. If using a fixed arm planimeter, multiply your number of revolutions by the number of square feet (at map scale).

   Example: If map scale is 1″ = 50′, then 1 square inch on map = 2500 sq. ft.
   Number of sq. ft. x number of revolutions = Total sq. ft.
   2500 sq. ft. x 1 revolution = 2500 sq. ft.

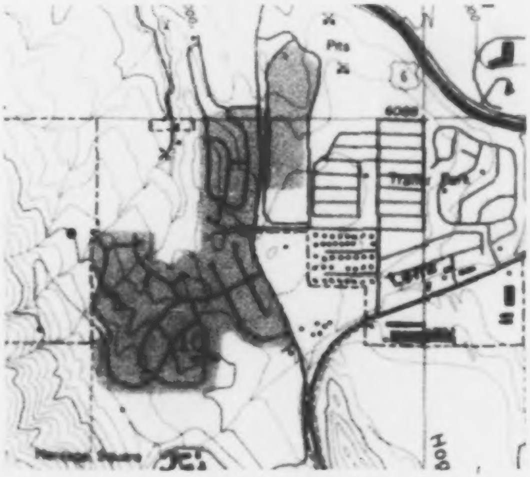
6. Divide the number of square feet in one acre (43,560 sq. ft. in 1 acre) into the number of square feet of the area being measured. This will give you the number of acres in the area to be measured.

   Example: 2500 sq. ft. ÷ 43,500 sq. ft. = .057 acres

7. For greater accuracy of results, planimeter each area three times and average the results.

Problem 1

Figure 1



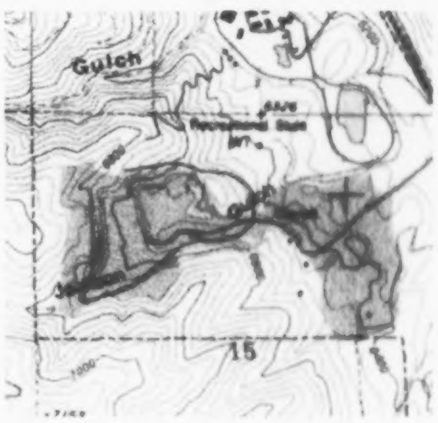
Using the planimeter, measure the solid gray area on Figure 1.
Map scale: 1″ = 2000′

a. 1 sq. inch on map (in scale) = ________________
b. Number of sq. inches measured with planimeter ________________
c. Number of sq. feet in measured area ________________
d. Sq. feet divided by 43,500 sq. ft. = ________________ acres

Note: Answers may vary due to paper shrinkage.

Problem 2

Figure 2



Using the planimeter, measure the solid gray area on Figure 2.
Map scale: 1" = 2000'

a. 1 sq. inch on map (in scale) = ________________
b. Number of sq. inches measured with planimeter ________________
c. Number of sq. feet in measured area ________________
d. Sq. feet divided by 43,500 sq. ft. = ________________ acres

Note: Answers may vary due to paper shrinkage.

Problem 3

Using a local 7.5 minute quadrangle map, select an area to measure.

a. 1 sq. inch on map (in scale) = ________________
b. Number of sq. inches measured with planimeter ________________
c. Number of sq. feet in measured area ________________
d. Sq. feet divided by 43,500 sq. ft. = ________________ acres

Problem 4

Using a local 7.5 minute quadrangle map, select an area to measure.

a. 1 sq. inch on map (in scale) = ________________
b. Number of sq. inches measured with planimeter ________________
c. Number of sq. feet in measured area ________________
d. Sq. feet divided by 43,500 sq. ft. = ________________ acres

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Objective 23

Assignment Sheet 2—Interpolate Contours From a Grid Survey and Prepare Profiles From the Contour Map

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• All contours are correctly labeled	______
• Sections and elevation correctly labeled	______
• Assignment is neat and legible	______

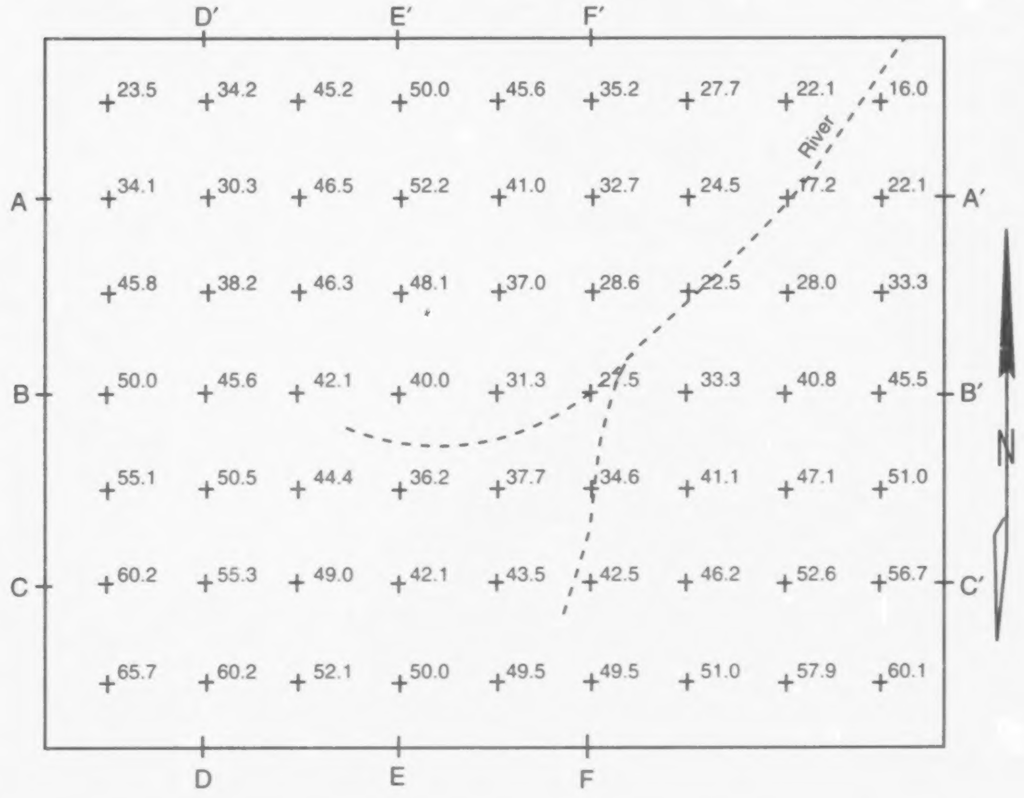
Basic Skills

Reading Mathematics Critical Thinking

Assignment Sheet 2

Part 1 Interpolate contours from a grid survey

Directions Refer to Student Supplement 5, “Manual Methods for Plotting Contour Lines,” for the step by step instructions for interpolating contours from a grid survey.


D′
E′
F′
23.5 34.2 45.2 50.0 45.6 35.2 27.7 22.1 16.0
River
A
34.1 30.3 46.5 52.2 41.0 32.7 24.5 17.2 22.1
A′
45.8 38.2 46.3 48.1 37.0 28.6 22.5 28.0 33.3
B
50.0 45.6 42.1 40.0 31.3 27.5 33.3 40.8 45.5
B′
N
55.1 50.5 44.4 36.2 37.7 34.6 41.1 47.1 51.0
C
60.2 55.3 49.0 42.1 43.5 42.5 46.2 52.6 56.7
C′
65.7 60.2 52.1 50.0 49.5 49.5 51.0 57.9 60.1
D
E
F

Given: Elevations plotted on a grid for a contour map. Horizontal scale: 1 in. = 20 ft.

Complete the contour map above.
Use contour interval (CI) = 5 ft.
Label all contours.

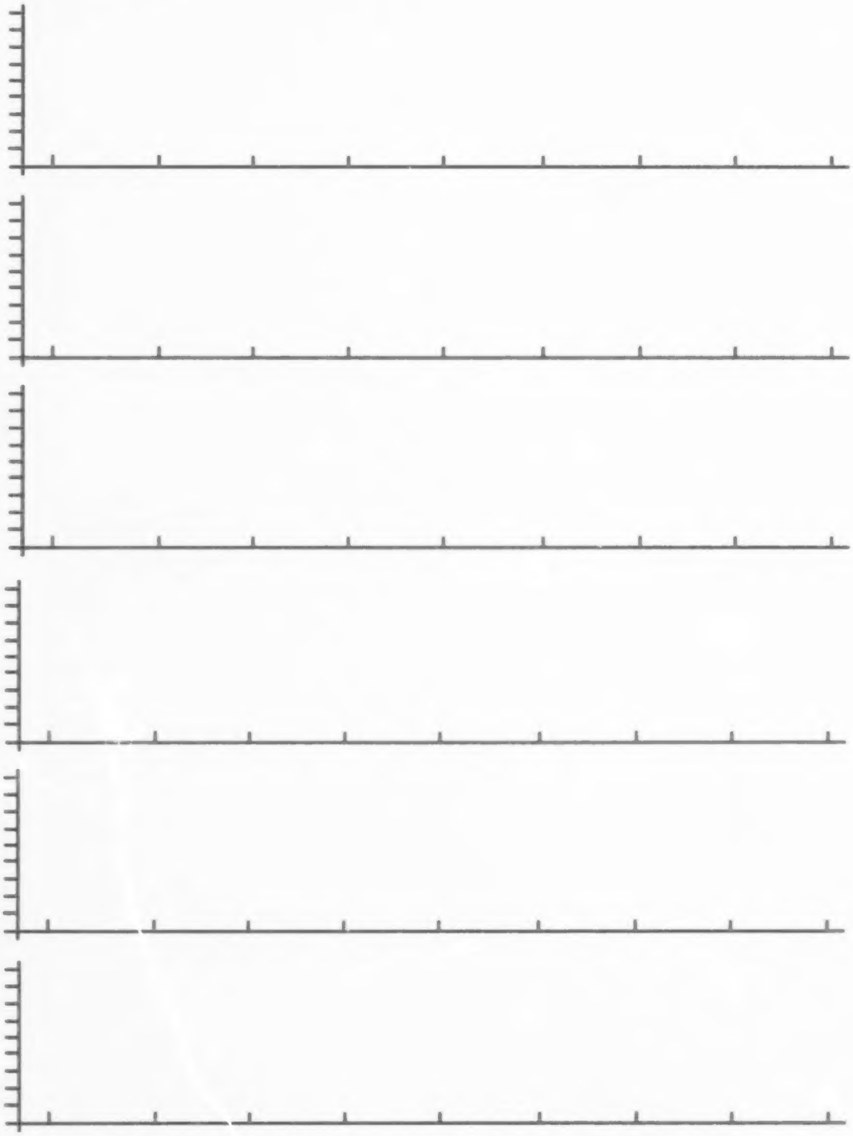
Part 2

Plot the profiles that are indicated on the contour map in Part 1. Plot A-A′ through F-F′.

Directions

Refer to Student Supplement 4, "Methods for Developing a Profile," Method 2, developing a profile from a contour map, for step by step instructions.

Use horizontal scale: 1 in. = 20 ft, vertical scale: each given mark = 5 ft.
Label sections and elevation.



Objective 24

Assignment Sheet 3—Calculate Grades

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Answers are mathematically correct	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics Critical Thinking

Directions

Refer to Student Supplement 6, "Fixing a Grade Line," for instructions on how to calculate the grade. Then calculate the grade for the following situations.

	Elevation	Horizontal Distance
A.	from 690.0 to 697.0	13 feet
B.	from 935.5 to 885.5	27 feet
C.	from 50.2 to 59.9	7 feet
D.	from 234.5 to 277.6	257 feet
E.	from 356.0 to 234.4	375 feet

Show grade in percentages.

A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

Objective 25

Assignment Sheet 4—Build a TIN and Make Contours

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• TIN created according to instructions	______
• Contour lines drawn correctly	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Directions

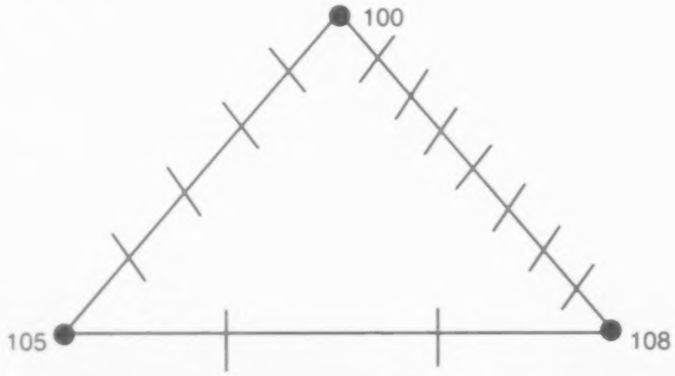
This assignment will require a civil CAD software program. You will follow the step by step procedure given in your particular software package to make a TIN.

First

You will be creating a network of triangles from data points and break lines that describe the MAVCC topo survey site.

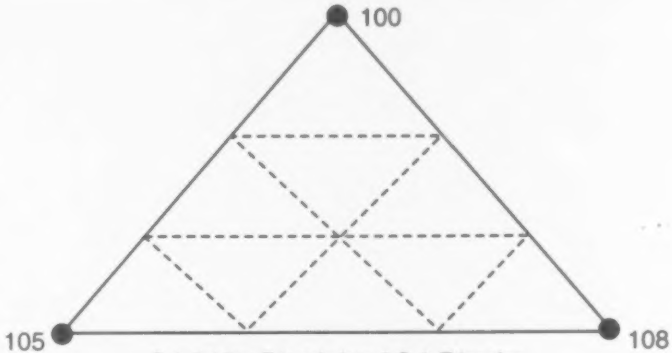
Second

You will create contour lines based on the TIN you just created. Contour lines come into the drawing as polylines at the appropriate elevations. The contour option interpolates contours from the TIN which was constructed to represent a surface. The contour map is constructed from a TIN by interpolation along the side of each triangle.



Interpolating the Points

Courtesy of Eagle Point Software



Subdividing Triangle Into 9 Sub-Triangles

Courtesy of Eagle Point Software

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Unit 8

Municipal Mapping, Plats and Subdivisions

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2—Reduce Field Notes and Plot a Simple Boundary Survey 8–41
3—Develop From Field Notes the Plat Map for a Nine-Lot Subdivision 8–43
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6—Research the Plats for Local Utilities 8–61

Objective Sheet

Unit Objective

After completing this unit, the student should be able to lay out a plat from a legal description and field notes and redraw to scale a complete final plat of a 36-lot subdivision. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to municipal mapping, plats, and subdivisions with their definitions.
2. Define subdivision planning.
3. Select from a list the official agents who may regulate subdivision planning.
4. List elements to consider when developing a parcel of land.
5. Match resource maps and documents used in land development with their descriptions.
6. Complete statements concerning types of plans.
7. List types of utilities.
8. List agencies that develop and maintain municipal maps.
9. List users of municipal maps.
10. Select from a list types of drawings used in municipal mapping.
11. List methods of presenting utilities on maps.
12. List five types of support information needed to develop utility drawings for a specific area.
13. Match colors used to represent different utilities.
14. Complete statements concerning utility easements.
15. List information included on utility drawings.
16. Match types of valves and valve housings with their definitions.
17. Match types of sewers and sewer lines with their descriptions.
18. Select true statements related to water lines.

Objective Sheet

19. Match types of gas piping and devices with their definitions.

20. Define a geologic report.

21. Select true statements about a soils report.

22. Define the purpose of a site analysis.

23. List items to be considered when conducting a site analysis.

24. List types of reports and permits required for a development site.

25. Arrange in order the steps in planning a subdivision.

26. Complete statements concerning the final recordation of a subdivision plat map.

27. Select individuals who certify and approve the final plat map.

28. Complete statements concerning legal descriptions.

29. Define GIS.

30. List applications for GIS.

31. Select true statements about the advantages of GIS.

32. Complete statements concerning what makes GIS work.

33. Select true statements about GIS and data integration.

34. Lay out a boundary survey from a legal description. (Assignment Sheet 1)

35. Reduce field notes and plot a simple boundary survey. (Assignment Sheet 2)

36. Develop from field notes the plat map for a nine-lot subdivision. (Assignment Sheet 3)

37. Redraw to scale a complete final plat of a 36-lot subdivision. (Assignment Sheet 4)

38. Research the plat information for your property or a property in your area. (Assignment Sheet 5)

39. Research the plats for local utilities. (Assignment Sheet 6)

Information Sheet

Objective 1

Terms and definitions

a. **Base map**—A map that shows roads, highways, ditches, rivers, lakes and subdivisions

b. **Benchmark**—A relatively permanent material object, natural or artificial, bearing a marked point whose elevation above or below an adopted datum is known

c. **Cadastral survey**—A survey which creates, marks, defines, retraces, or reestablishes the boundaries and subdivisions of the land

d. **Compaction**—The degree of soil compressibility

Note: A typical engineered base for structures, the soil is 95% compacted.

e. **Corner**—A point on the surface of the earth, determined by the surveying process, which defines an extremity on a boundary of public lands

f. **Corner description**—The specific data (both old and new) about a corner monument and its accessories, which include marks, positions, and physical characteristics

g. **Cul-de-sac**—A dead-end street which widens sufficiently at the end to permit an automobile to make a "U" turn

h. **Datum line**—In ordinary survey usage, a defined reference line for survey measurement

i. **Distribution map**—A map that contains one-line configurations of all overhead and underground primary and secondary utility lines

j. **Easement**—An interest or right in land owned by another that entitles its holder to a specific limited use, such as laying a sewer, crossing over property, or putting up power lines

k. **Flow diagram**—Drawing that shows a system in a symbolic manner as opposed to conventional mapping format

l. **Grade plan**—A plan containing original ground contours over which contours of highway, subdivision, or other embankment or excavation to be completed are superimposed on and connected with the original ground contours at the edge of construction limits

m. **Groundwater**—Subsurface water that saturates pores or cracks in soil or rocks; stored in and moves through moderately to highly permeable rocks called aquifers

n. **Grubbing**—The clearing of roots and stumps from the ground

o. **Hydrology**—Scientific study of the waters of the earth and the effects of water in the earth's atmosphere, on the earth's surface, and below the earth in the soil and rock

p. **Index map**—A map that shows the location of all plats and plat numbers

q. **Infiltration rate**—Time it takes for water to seep into the soil, or rate at which groundwater seeps into sewer line

r. **Invert**—Inside bottom of a pipe; the flow line

s. **Land use classification system**—Coding system of categories and subcategories designed for use on a map to designate land or water use

t. **Lateral**—Pipe connecting a utility main to facilities at the sides

u. **Legal description**—A written statement recognized by law as to the definite location of a tract of land by reference to a survey, recorded map, or adjoining property

v. **Monument**—A physical structure, such as an iron post, marked stone, or tree in place, which marks the location of a corner point established by a cadastral survey

w. **Municipal mapping**—The recordation of public utilities such as gas, electric, water, and sewer lines onto a map for public record

x. **Overt**—Inside top of a pipe

y. **Peak flow**—Maximum instantaneous flow

z. **Percolate**—To pass through a porous material

aa. **Plan**—Design or list of steps to accomplish some task; usually, drawings made to scale that show necessary information for construction of structures

bb. **Planning commission**—Either a citizen committee appointed by the chief executive or legislative body to review subdivision plans, or a full- or part-time staff of professional planners hired to carry out continued planning activities, review subdivision plans, conduct studies, etc.

cc. **Plat, subdivision**—A map of a subdivision of land usually prepared in accordance with state plat statutes or local subdivision regulations or both

dd. **Plat, use**—The component of the new status records, a copy of the master title plat which shows in addition to survey, ownership, and restrictive data, leases, licenses, and permits currently effective

ee. **Platting**—The process of preparing a plat or subdivision according to state and local ordinances ff. **Plot**—To place survey data upon a map or plat

Note: In the past, no clearly defined difference existed between plat and plot. It is recommended to use plat for graphic representation of the survey and plot for the cartographic operations involved in the construction of a map or plat.

gg. **Slope**—The horizontal distance necessary for each foot of vertical height

Example: 2:1 slope = 1 foot of vertical difference for every 2 feet of horizontal distance

Note: The allowable slope is based on the angle of repose for the soil.

hh. **Subdivision plat book**—A public record showing the location, size, and name of owners of various recorded plats in the municipality or county

ii. **Subgrade**—Material placed below the surface to provide a stable foundation for structures

Objective 2 **Subdivision planning**—The process of dividing urban land into orderly, accurately surveyed parcels

Objective 3 **Official agents who may regulate the subdivision of land**

a. City and county planning commission
b. City council
c. County commissioners

Objective 4 **Elements to consider when developing a parcel of land**

a. Resources
b. Public agencies
c. Site analysis
d. Preliminary design
e. Preliminary engineering
f. Geologic report
g. Soils report
h. Earthwork: grading and quantities
i. Roadways and parking lots
j. Sanitary sewers
k. Storm drainage
l. Water supply lines

m. Regulations for building heights, parking facilities, and right-of-way setback lines

n. Utility regulations

Objective 5

Resource maps and documents used in land development

a. Street map—Shows location of streets in relation to land to be developed

b. Aerial map—Used in the planning stages of a project for planning locations, for presentation to the public or base maps

c. Zoning map—Shows zoning districts which aids in land use decisions

d. Assessor's parcel map—Tax map that identifies land ownership and overall boundary information which is useful in early development stages

Note: Graphic is not legal property lines.

e. USGS/USC&GS maps—Provide large scale data for an area regarding topography, well locations, vegetation, and other natural features

f. Deed—Legal description of the property

g. Title report—Document prepared by title insurance company which provides the legal description and any claims to the property in the form of easements, taxes, mortgages, mineral or water rights. This report may include limitations for development.

h. Survey map—Accurate map that verifies topography and property lines through a field survey

i. Spread sheet—A computer-generated document that is used to chart cost estimates, earth work calculations, etc.

j. Parcel map—Shows exact legal location and description of plots of land

k. Subdivision map—Required if more than five parcels are created

Objective 6

Types of plans

a. Master plan—Shows how one site relates to the larger plan in the community

b. Demolition plan—Shows what the contractor should save or demolish at the site

c. Grading plan—Shows the elevations and slope of the site

d. Construction/improvement plan—Shows the horizontal and vertical locations of the structures and necessary details

e. Traffic plan—Shows signalization, signage, lighting, striping, and guardrails of a road project

f. Landscaping plan—Shows location and types of trees and plants, irrigation, and lighting

g. Utility trench plan—Shows the location of power and communication lines

h. As-built plan—Shows the final location of all items on the site; the final set of construction plans

Objective 7

Types of utilities

a. Gas

b. Electric

c. Water

d. Sewer

e. Telephone

f. Cable for television

g. Drainage

Objective 8

Agencies that develop and maintain municipal maps

a. Public service companies

b. Rural power companies

c. Department of public works

d. Department of waste management

e. Telephone company

f. Water department

Objective 9

Users of municipal maps

a. Architects

b. Land developers

c. City planners

d. Telephone company

e. Builders

f. Zoning department

g. Individuals

h. Engineers

i. Surveyors

Objective 10

Types of drawings used in municipal mapping

a. Plan

b. Profile

Note: Some utilities require engineering plan and profiles, while others such as water and telephone can be located by easements over lots on plat maps.

c. Plat maps

d. Base maps

e. Flow diagrams

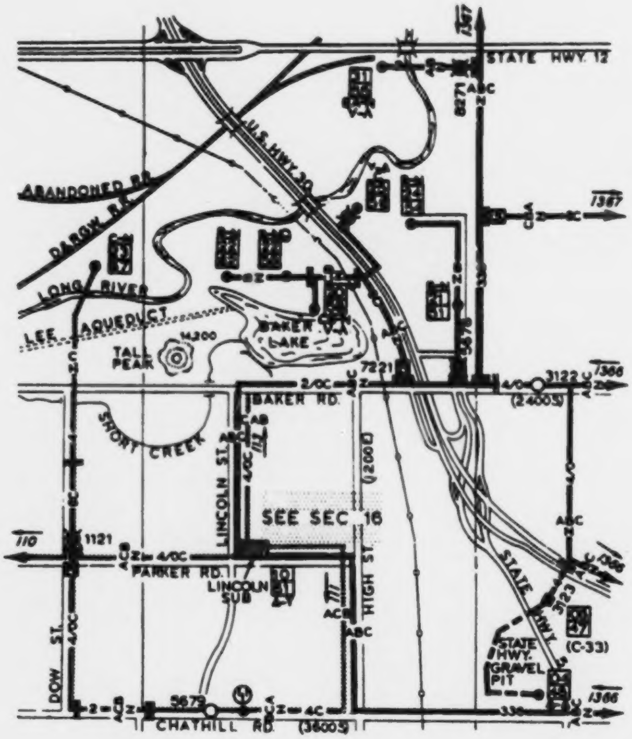
f. Bill of materials (quantity sheets, spread sheets)

g. Distribution maps

h. Obstruction maps

i. Index maps

Figure 1—Typical Distribution Map (Electric)


STATE HWY. 12
1367
8271
ABC
U.S. HWY. 30
ABANDONED R.R.
DAROW R.R.
1367
LONG RIVER
LEE AQUEDUCT
14,200
TALL PEAK
BAKER LAKE
7221
5876
2/0C
BAKER RD.
4/0
3122
(24005)
1366
SHORT CREEK
LINCOLN ST.
4/0C
(2001)
SEE SEC. 16
110
1121
4/0C
PARKER RD.
LINCOLN SUB
HIGH ST.
ABC
STATE HWY.
3123
(C-33)
STATE HWY. GRAVEL PIT
DOW ST.
5679
4C
CHATHILL RD.
(36005)
330
1366

Objective 11

Methods of presenting utilities on maps

a. Separate maps for each utility

b. Base map with overlays to show the location of each utility

c. Composite maps

d. CAD—Each utility can be stored on a separate layer in the computer. A computer printout can provide just the base map or the location of as many utilities as the operator wants plotted out.

e. Graphic information software (GIS)

Objective 12

Support information needed to develop utility drawings for a specific area

a. Adjacent plats

b. Miscellaneous information on subs, ordinances, and deed pertaining to plat to be drawn

c. Aerial photos

d. Railroad maps

e. Highway maps

f. USGS maps

g. Easement file

h. Transmission pipeline plats

i. Obstruction maps

j. Electric transmission right-of-way

Objective 13

Color codes used to represent different utilities

Note: Utility lines should be labeled in addition to the color identification.

Example: The following color code is used by one company. This varies between companies.

a. Gas—Yellow

b. Water—Red or blue

c. Sanitary sewer and storm sewer—green/orange

d. Telephone—green or orange

e. Electric—Purple or red

f. Steam—Blue and yellow dashed

g. Petroleum pipelines—Helio

h. Radar and missile cables—Yellow and helio dashed

i. F.O.—Orange

Objective 14

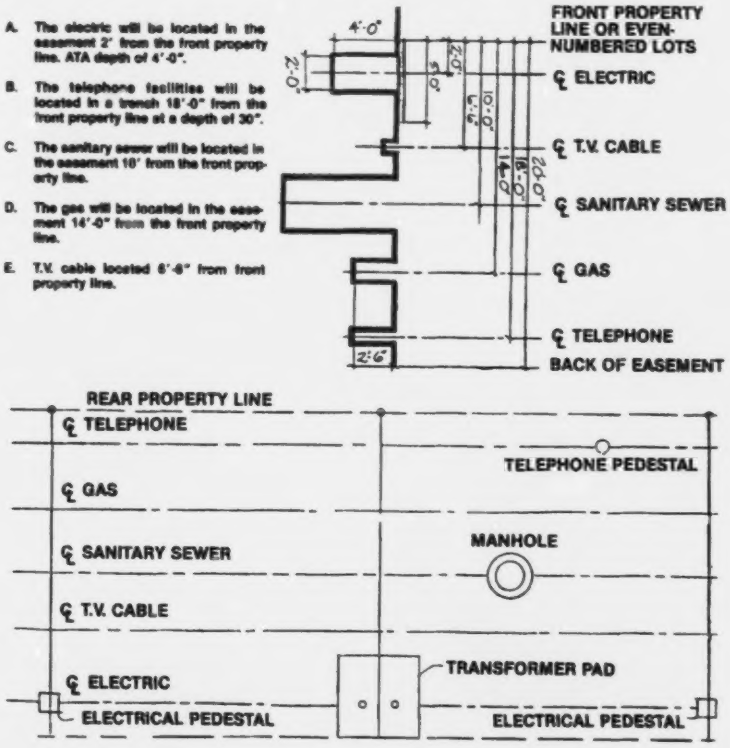
Utility easements

a. Are usually shown on the subdivision plat to indicate the location of any and all utilities

Note: This location is not generally used for gas mains.

b. Generally each utility will be located in a standard location with reference to the front property line

Figure 2—Typical Utility Easement Layout



A. The electric will be located in the easement 2' from the front property line. ATA depth of 4'-0".

B. The telephone facilities will be located in a trench 18'-0" from the front property line at a depth of 30".

C. The sanitary sewer will be located in the easement 10' from the front property line.

D. The gas will be located in the easement 14'-0" from the front property line.

E. T.V. cable located 6'-6" from front property line.

FRONT PROPERTY LINE OR EVEN-NUMBERED LOTS
4'-0"
2'-0"
2'-0"
5'-0"
6'-6"
10'-0"
14'-0"
18'-0"
20'-0"
2'-6"
℄ ELECTRIC
℄ T.V. CABLE
℄ SANITARY SEWER
℄ GAS
℄ TELEPHONE
BACK OF EASEMENT
REAR PROPERTY LINE
℄ TELEPHONE
TELEPHONE PEDESTAL
℄ GAS
MANHOLE
℄ SANITARY SEWER
℄ T.V. CABLE
℄ ELECTRIC
TRANSFORMER PAD
ELECTRICAL PEDESTAL
ELECTRICAL PEDESTAL

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Objective 15

Information included on utility drawings

a. Easement dimensions

b. Symbols and labels

c. Bill of materials

d. Schematic symbols for fittings, valves, sewer lines, water lines, and taps

e. Manhole locations

f. Distance of gas main, sewer line, or water tap from property line

g. Sizes and types of valves and lines

h. Locations of obstructions

i. Existing and proposed utility lines

j. Underground cables

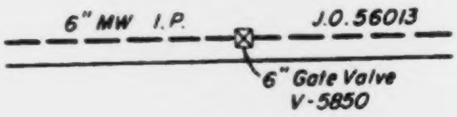
k. Street lighting symbols (depending on type of drawing)

Objective 16

Types of valves and valve housings

a. Gate valve—Used for infrequent start-stop operations; has a disk to stop flow through valve

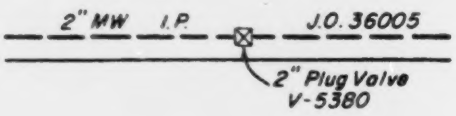
Figure 3



b. Ball valve—Used for quick start-stop operations; has a ball to stop flow through valve

c. Plug valve—Used for quick start-stop operations; has a slotted core or plug that stops flow when turned 90°

Figure 4



d. Globe valve—Used for flow regulation, throttling, and frequent operation

e. Check valve—Used to prevent backflow; available as swing check or lift check for different applications

f. Pressure safety valve—Used to protect equipment and workers from sudden and dangerous excess pressures

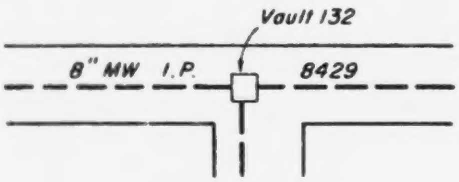
g. Pressure regulator valve—Used to automatically maintain accurate, constant, and uniform flow in a line

h. Valve box—A small box designed to house a valve up to and including 6"

i. Valve vault—An underground structure designed to house a valve 8" and larger or a series of valves

Note: Vaults are usually built of reinforced concrete and are constructed in several standard sizes.

Figure 5



Objective 17

Types of sewers and sewer lines

Note: Most sewers are concrete pipe (old) or PVC (new).

a. Storm sewer—Collects rain wash and fire water

b. Process sewer—Collects water from drains of equipment, drips from pumps, and other dirty drains

c. Combined sewer—Collects both storm and process sewers utilizing only one piping system

d. Sanitary sewer—Carries human waste

e. Funnel—Liquid collection point that usually projects about 2" above the finished grade

f. Branches—Lines (4" minimum) that collect from various drain funnels or catch basins and tie to sublaterals

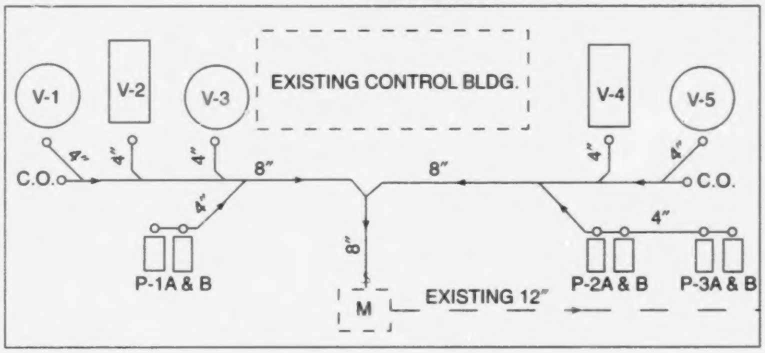
g. Laterals—Sewer lines collecting from two or more sublaterals and discharging to mains through a sealed manhole

h. Sewer mains—Lines that collect flow from two or more laterals and are usually located in roadway easements; are sealed at regular intervals with manholes to prevent the spread of fire or gas backup

i. Cleanouts—Openings located at the ends of branches and long line runs which allow the sewer to be cleaned by removing a plug and inserting a long flexible steel bar

Figure 6—Typical Flow Diagram (Sewer Layout)

V	Vessel	o—	Drain Funnel
P	Pump	o-S-	Drain funnel with Seal or Running Trap
T	Tank		
M	Manhole	→S M	Manhole with Sealed Inlet
CB	Catch Bas	→S CB	Catch Basin with Sealed Outlet
		←CO	Cleanout



Objective 18

Information related to water lines

a. Water lines may be designed to go over or under other underground facilities because they are not dependent on gravity to flow.

Note: Water lines are pressure lines.

b. Water company will dictate the size, location, and types of pipes to be used.

c. Water lines may have standard locations dependent on local regulations.

d. Water lines for drinking water must be protected from infiltration.

e. Water lines should never be placed in the same trench with the storm drain and sanitary sewer lines.

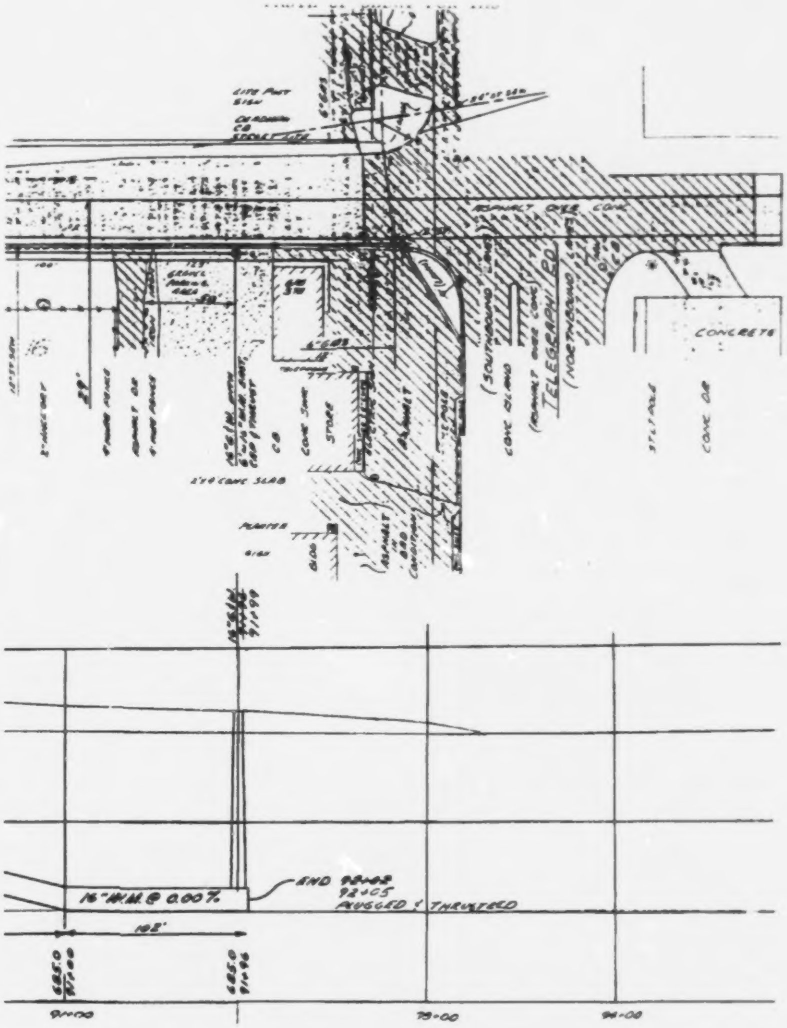
Note: A 10-foot distance should be maintained between water and sewer lines.

f. Water lines are laid out in a gridlike manner so there are no unconnected ends. This is called looping.

g. Centers of water pipelines are aligned as opposed to alignment of the overt of the pipes.

h. Water lines are a closed system and wherever there is a change of direction a thrust block is provided to accept the momentum of the water force.

Figure 7—Typical Plan and Profile (Water System)


ASPHALT OVER CONC
TELEGRAPH RD
(SOUTHBOUND LANES)
(NORTHBOUND LANES)
CONC ISLAND
CONCRETE
4'x4' CONC SLAB
PLANTER
16" W.M. @ 0.00%
END 92+05
PLUGGED & THRUSTED
102'
685.0
685.0
91+00
93+00
94+00

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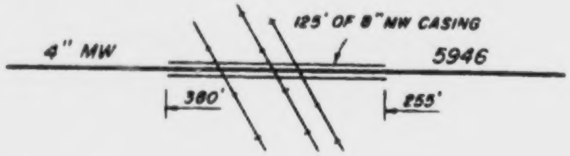
Objective 19

Types of gas piping and devices

a. Casing—Pipe sleeve generally used for railroad, highway, ditch, and bridge crossing to enclose the main in a protective casing

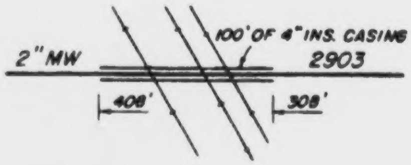
Figure 8


4" MW
125' OF 8" MW CASING
5946
380'
255'

b. Casing, insulated—Same as casing, but carrier is insulated from pipe with insulated spacers and bushings

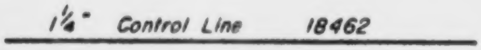
Note: All casing should be insulated from carrier pipe.

Figure 9


100' OF 4" INS. CASING
2" MW
2903
408'
308'

c. Control line—A small pipe, usually 3/4" or 1 1/4", used in connection with a regulator station to control pressure rather than to transport gas

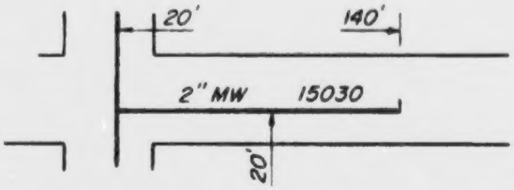
Figure 10


1¼" Control Line 18462

d. Cover—Distance between top of pipe and street surface

e. Main ending—Distance to end of main from a stationary point such as property line, pole line, etc.

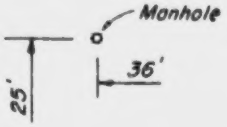
Figure 11


20'
140'
2" MW 15030
20'

f. Manhole—An opening at the top of a valve vault making housed valves accessible at all times

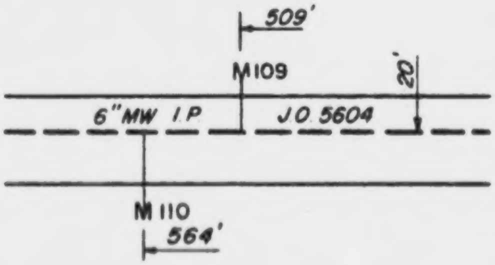
Note: In some areas the entire structure is referred to as the "manhole."

Figure 12



g. Marker, pipeline—A wooden post 8′ in length with metal warning signs on two sides in line with the pipeline installed directly over the main where measurements from a permanent object or source are not available

Figure 13



h. Meter—A device for measuring customer gas usage in cubic feet

i. Meter riser—A portion of piping vertical to the ground used for the installation of an outside meter

j. Nipple—A short piece of pipe

k. Pole line—Power or telephone line usually set 1 foot on road side of property line

l. Regulator station—Equipment designed to reduce and control gas pressure manually, automatically, or by remote control

Note: These vary in size from a small station on a pole (pole type) to a major station requiring a complete building and plot of ground.

m. Riser—Gas piping installed in a vertical position, usually exposed and fastened to building walls, poles, or other rigid structures

n. Service, low pressure—That portion of pipe used for transporting low pressure gas from the main to the meter

o. Service regulator—A device designed to reduce gas pressure and maintain constant pressure for customer's use; located between the service terminal valve and the gas meter

Information Sheet

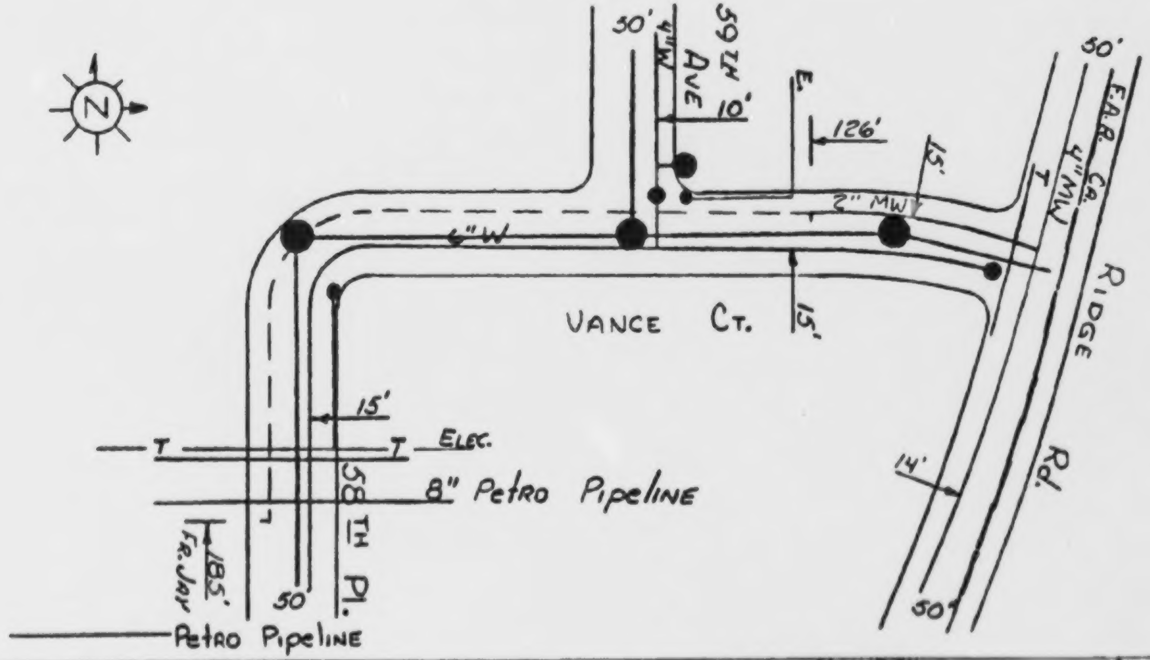

N
50'
59TH AVE
4" W
10'
E.
126'
15'
E.A.R. CA.
4" MW
T
2" MW
50'
4" W
VANCE CT.
15'
RIDGE
Rd.
15'
T
T
ELEC.
8" Petro Pipeline
58TH Pl.
14'
185'
FR. JAY
50
50'
Petro Pipeline

Figure 14—Typical Obstruction Map (and Proposed Gas Sketch)

LEGEND

Present Gas ————

Proposed Gas — — —

Range Lines ———— BROWN

Water Phone RED

Sewer Phone ORANGE

Telephone Phone GREEN

Electric Phone PURPLE

Steam Phone Blue & Yellow (ALT)

Western Union Phone Yellow/Black Edges

Pipe Protection

SYSTEM INFORMATION

Max Press.	Area Reg. Sta.
I.P. Press. Test	Press. System
Cath Cont. Equip.	Cont. Area
Tie-in	Wild Boost
	Elec. Outage

DATE

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Information Sheet

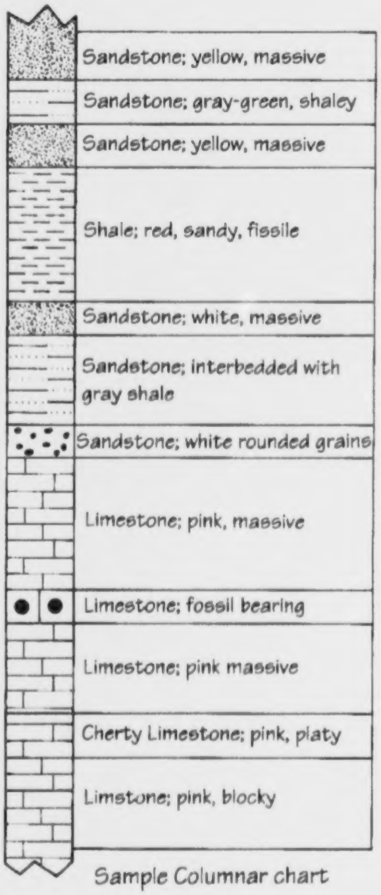
Objective 20

Geologic report

a. This report is constructed by a geologist.

b. The geologic history of the site and subsurface studies will be used to determine suitability for development.

Figure 15


Sandstone; yellow, massive
Sandstone; gray-green, shaley
Sandstone; yellow, massive
Shale; red, sandy, fissile
Sandstone; white, massive
Sandstone; interbedded with gray shale
Sandstone; white rounded grains
Limestone; pink, massive
Limestone; fossil bearing
Limestone; pink massive
Cherty Limestone; pink, platy
Limstone; pink, blocky

Sample Columnar chart

Objective 21

Soils report

a. This report and investigation is made by a soils engineer.

b. Core samples and boring are taken at the site to show the underlying strata below the surface.

c. The report will include information on the soils to determine strength, plasticity, potential for liquification, and permeability and the depth of the groundwater and compaction.

d. The soils report will provide useful information for the design of the structure, the paved surfaces and slopes and grading of the site.

Objective 22

Purpose of a site analysis—To provide an engineered feasibility study, cost estimates, and preliminary design for land development that includes purpose and limitations, location and description

Objective 23

Items to consider when conducting a site analysis

a. Description of location
b. Description of the environment
c. Description of the site
d. Existing zoning
e. Required zoning
f. Streets
g. Sanitary district
h. Flood control district
i. Water supply district
j. Utilities: electric, gas, telephone, cable tv
k. Grading

Objective 24

Reports and permits required for a development site

a. Air pollution
b. Traffic
c. Noise pollution
d. Water
e. Geological
f. Soils
g. Archeological
h. Historical
i. School impacts
j. Flood control district
k. Environmental impact report (EIR)

Objective 25

Steps in planning a subdivision

Note: Preliminary plats show all necessary information related to the site development so the town or county knows what to expect on the final development. The steps in planning a subdivision will vary from locale to locale. Consult the specific procedures used in your area.

a. Planning office and city engineer are consulted for governing rules and regulations of the local planning agencies specifying the following:

   - Frontage and depth of lots
   - Minimum and maximum length of blocks
   - Street widths
   - Maximum street gradients
   - Minimum street gradients
   - Allowable direction of lot lines in respect to the streets
   - Design consideration of residential subdivisions
   - Width of right-of-ways for city streets
   - Width of alleys
   - Minimum required clearance from residential buildings to property lines

b. A small scale location map is developed to show the relation of the subdivision to the surrounding properties.

c. A tentative plan is developed to show the following:

   - Outline of property
   - Proposed title of the subdivision

     Note: This should be checked with the planning office to ensure it is not already in use.

   - Drawn to a scale of 1" = 200' or larger

     Note: This is often drawn to the same scale as the final plat map, but not always.

   - Topographic features of existing conditions
   - Owner's and surveyor's name
   - Recorded titles of adjoining tracts

- Proposed layout of lots, streets, alleys, walkways, parks, and any special features
- All existing easements for a pipeline, power line, etc.
- Legal description of land (usually only in caption form)
- The following items will either have documentary references or an explanation of their status:
    - Water
    - Sewer
    - Flood and drainage conditions
    - Street improvements
    - School facilities
    - Parks and recreation
    - Power and street lights
    - Gas
    - Fire protection
    - Hospitals
    - Transportation
    - Access to highways

d. The tentative map is presented for review to the clerk of the advisory agency such as the planning commission.

e. After the tentative plan is approved and all changes are made, a final subdivision plat is drawn up, and then has to receive final approval from the appropriate governing agency.

Note: Refer to Student Supplement 1 for an example of typical preliminary plat guidelines.

Objective 26

The final recordation of a subdivision plat

a. The final plat is considered a legal working document and will be on file at the county courthouse.

b. It is drawn at a scale of 1" - 100' or larger.

c. Listed are some of the requirements for a final plat.

Note: Requirements for the final plat may vary in your locale. Check with the local governing agency for the requirements in your area. Refer to Student Supplement 2 for an example of a typical final plat check list.

- Legal description of the property
- Property lines, dimensions, and bearings
- Direction of north
- Proposed setback from all property lines

- Utility and drainage easements
- Total acreage
- Drawing scale
- Necessary signatures of certification

d. Title sheet will include:

- Certification signatures
- Caption type description
- Basis of bearing
- Monument note
- Benchmark, if required
- Legend, if required
- Omission of certain signature, if applicable
- Index map of subsequent sheets, if many
- North arrow and scale
- Soil test report, if required
- Any special notes

Note: Refer to Student Supplement 3 for a sample of title sheet information.

Objective 27

Individuals who certify and approve the final plat map

a. Private engineer or surveyor

b. Public engineer or surveyor

c. Financial institution—mortgage release

d. Title company—title opinion

e. Owner

f. City agent

g Utility companies

h. Clerk and recorder

Objective 28

Characteristics of legal descriptions

Note: Refer to Student Supplement 4 for an example of a legal description.

a. Are written descriptions describing the relationship of a parcel of land to the surrounding surveys

b. A complete description will begin with the broad overall division and progress to the small details

c. A complete description can include all three types of land descriptions:

- Public land sectional system to identify the point of beginning
- Metes and bounds to describe the boundary lines
- Lot and block description can be used as an alternate description

Figure 16

Public Land Sectional Description

All that part of the Northeast Quarter of the Northeast Quarter of Section 12, Township 5 North, Range 2 East of the Fifth Principal Meridian, Clarion Township, Walker County, and State of Missouri, described as follows:

Commencing at the Northeast Corner of said Section 12;
Thence on an assumed bearing of South 89°58′40″ West on and along the north line of Section 12 a distance of 825.00 feet to the point of beginning;
Thence South 0°02′20″ West a distance of 721.78 feet;
Thence South 89°58′40″ West a distance of 320.22 feet;
Thence North 31°18′20″ West a distance of 844.57 feet to the said north line of Section 12;
Thence North 89°58′40″ East a distance of 759.55 feet on and along the said north line of Section 12 to the point of beginning.

ALSO known as Lot 5, Block 4, Oak Hills Subdivision, Walker County, Missouri.

Lot and Block Description

Metes and Bounds Description

Objective 29

Geographic Information Systems (GIS)—Is a computer system, capable of assembling, storing, manipulating, and displaying geographically referenced information; for example, data identified according to their locations

Objective 30

Applications for GIS

a. Scientific investigation

b. Resource management

c. Development planning

d. Tax mapping

e. Planning and land use

f. Voter and school districting

g. Emergency response

h. Public utility management

Objective 31

Advantages of GIS

a. Map data is more secure and better organized.

b. Redundancy of multiple map sets is eliminated.

c. Map revisions are easier and faster.

d. Data is easier to analyze, search and present.

e. Map data is integrated throughout the organization.

Objective 32

What makes GIS work

a. The primary requirement for source data is that the locations for the variables are known. Locations may be annotated by x, y, and z coordinates of longitude, latitude, and elevation.

b. A system like zip codes or highway mile markers can be used.

c. Any variable that can be located spatially can be fed into a GIS.

d. A GIS can convert existing digital information, which may not yet be in map form, into forms it can recognize and use.

Example: Census or hydrologic tabular data can be converted to a map-like form.

Objective 33

GIS and data integration

a. GIS makes it possible to link or integrate information that does not associate automatically by transforming digital information gathered from sources with different map projections to a common projection.

b. Data restructuring can be performed by a GIS to convert data into different formats.

c. GIS can be used to depict two- and three-dimensional characteristics of the earth's surface, subsurface, and atmosphere from information points.

Example: GIS can generate a map with lines that indicate rainfall amounts.

Student Supplement 1—Typical Preliminary Plat Guidelines

☐ Any preliminary plat submitted for subdivision approval shall be drawn to a scale of no less than one inch equals one hundred feet, but of a sufficient scale to be clearly legible, including streets and lots adjacent to the subdivision.

☐ The proposed name of the subdivision.

☐ Location and boundaries of the subdivision, names of all abutting subdivisions with lines indicating abutting lots, or if the abutting land is unplatted, a notation to that effect, and names of all abutting streets.

☐ Contours at one-or two-foot intervals if the slope is less than ten percent and five feet where the slope is greater than ten percent.

☐ Date of preparation, scale, and north sign (designated as true north).

☐ A vicinity map showing at least three blocks on all sides of the proposed subdivision, which may be of a different scale than the plat.

☐ Location of structures and trees of five-inch caliper or more on the property and approximate location of structures off the property within ten feet of the property line.

☐ Name, address, and telephone number of the licensed surveyor, licensed engineer, or designer of the plat.

☐ Name, address, and telephone number of owner and verification of ownership of the property and current title information by either a preliminary title report or an attorney memorandum based upon an abstract of title, current as of the date of the submittal.

☐ Total acreage.

☐ Location and dimensions of all proposed public improvements, easements, drainage areas, irrigation ditches and laterals, and other significant features within or adjacent to the property.

☐ Location and dimensions of all proposed public improvements, public easements, lot lines, and parks and other areas to be reserved or dedicated for public use.

☐ Geological stability information upon request of the City Manager if the manager determines or the subdivider has any reason to believe that building or other problems may arise from construction in the area proposed for development.

☐ Zoning on and adjacent to the property.

☐ Designation of areas subject to the one-hundred year flood and the estimated flow rate used in determining that designation.

☐ The number of lots and each lot size.

☐ Proposed use of each lot.

☐ Proposed ownership and use of outlots.

☐ The location and size of existing utilities within or adjacent to the property including without limitation, water, sewer, storm sewers and drainage facilities, fire hydrants within three hundred fifty feet of the property, electricity, and gas, which shall be placed on separate engineering drawings.

☐ A master utility plan showing proposed plans for private and public utility systems including water, sewer, electric, gas, drainage, telephone, telecommunications, and any other services that will supply the property.

☐ Names and addresses of all tenants of the property and all owners of property abutting the property.

☐ Identification of the public improvements, easements, parks, other public facilities shown on the plat and a dedication thereof to the public use, and areas reserved for future public acquisition.

790

Student Supplement 2—Typical Final Plat Check List

- ☐ A map of the plat drawn at a scale of no less than one inch equals one hundred feet (and of a sufficient scale to be clearly legible) with the use of permanent lines in ink and whose outer dimensions of the map at 24" x 36" on a reproducible polyester film (maps of two or more sheets shall be referenced to an index map placed on the first sheet).
- ☐ A one inch equals one hundred feet reduction of the plat.
- ☐ The title under which the subdivision is to be recorded.
- ☐ Accurate dimensions for all lines, angles, and curves used to describe boundaries, public improvements, easements, areas to be reserved for public use, and other important features. All curves shall be circular arcs and shall be defined by the radius, central angle, tangent, arc, and chord distances. All dimensions, both linear and angular, are to be determined by an accurate control survey in the field that must balance and close within a limit of one in ten thousand. No final plat showing plus or minus dimensions will be approved.
- ☐ Names of all abutting subdivisions, or if the abutting land is unplatted, a notation to that effect.
- ☐ An identification system for all lots, blocks, and names for streets.
- ☐ An identification of the public improvements, easements, parks, other public facilities shown on the plat and a dedication thereof to the public use, and areas reserved for future public acquisition.
- ☐ The total acreage and surveyed description of the area.
- ☐ The number of lots and size of each lot.
- ☐ Proposed ownership and use of outlots.
- ☐ A designation of areas subject to the one-hundred year flood, the estimated flow rate used in determining that designation, and a statement that such designation is subject to change.
- ☐ A description of all monuments, both found and set, that mark the boundaries of the property, and a description of all control monuments used in conducting the survey.
- ☐ A statement by the land surveyor that the survey was performed in accordance with state law.
- ☐ A statement by the land surveyor explaining how bearings, if used, were determined.

☐ The signature and seal of the state registered land surveyor.

☐ A delineation of the extent of the one-hundred year flood-plains, the effective date thereof, and a statement that they are subject to change.

☐ Square footage of each lot.

☐ Certification for approval by the following:

A) Director of Planning and Community Development
B) Director of Public Works and Utilities
C) Director of Parks and Recreation
D) Director of Real Estate and Open Space
E) Telephone Company
F) Public Service Company

☐ Signature blocks for all owners with an interest in the property.

☐ Signature block for Mayor's signature.

☐ Engineering drawings for proposed public and private utility systems meeting the requirements of the City Public Works Department's "Design Criteria and Standard Specifications."

☐ An update to the preliminary title report or attorney memorandum based upon an abstract of title current as of the date of submitting the plat.

☐ Covenants for maintenance of private utilities or improvements, as prescribed.

☐ Copies of documents granting any easements required as part of the plat approval, the County Clerk and Recorder's recording number, and proof of ownership of the property underlying the easement satisfactory to the City Attorney.

☐ The subdivider shall provide to the City a computer check to assure that the exterior lines of the subdivision on the final plat close. In the absence of such verification, the City shall obtain such computer check, and the subdivider shall pay the fee therefore prescribed before recording the plat.

☐ When submitting a final plat, the subdivider shall also file with the City Manager fees prescribed, agreements with ditch companies, if needed, engineering plans, and financial guarantees required.

Student Supplement 3—Sample of Title Sheet Information

ARBOR GLEN SUBDIVISION

FINAL PLAT

A SUBDIVISION OF A PART OF SECTION 17, T 1 N, R 70 W
OF THE 6TH PM, COUNTY OF BOULDER, STATE OF COLORADO

LEGAL DESCRIPTION

A part of the Southwest Quarter of the Northwest Quarter of Section 17, Township 1 North, Range 70 West, 6th Principal Meridian, described as follows

BEGINNING AT THE WEST QUARTER CORNER OF SAID SECTION 17
Thence N 89°38'05" E, a distance of 646.48 feet,
Thence N 0°21'55" W, a distance of 35.00 feet,
Thence N 54°38'11" E, a distance of 120.03 feet,
Thence Northwesterly 768.07 feet along the arc of a curve to the left, said curve having a radius of 2799.50 feet, a delta angle of 15°43'11", and being subtended by a chord that bears N 43°13'25" W, 765.67 feet,
Thence N 51°05'00" W, a distance of 214.40 feet,
Thence S 38°55'52" W, a distance of 88.33 feet,
Thence S 0°12'00" E, a distance of 732.50 feet
to the POINT OF BEGINNING

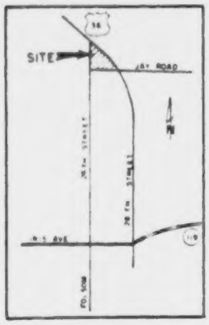
Area = 8.54 acres more or less

NOTES

1 o PINS SET BY DREXEL BARRELL AND CO L.S. 17664

2 SITE IS NOT WITHIN 100 YEAR FLOOD PLAIN FOR FOUR MILE CREEK

1 ● PINS SET BY ROBERT ORTHMAN L.S. 15315



VICINITY MAP
1" = 2000'

MAYOR'S CERTIFICATE

THIS IS TO CERTIFY THAT THE CITY OF BOULDER, COLORADO ADOPTS AND APPROVES THE WITHIN PLAT AND ACCEPTS THE DEDICATIONS HEREON MADE

____
MAYOR

____
DIRECTOR OF FINANCE AND RECORD
EX-OFFICIO CITY CLERK

OWNER'S SIGNATURE

FOR APPROVAL OF ARBOR GLEN SUBDIVISION AND CONDITIONS WHICH APPLY THERE TO

BY ____________________ __________
M.L. MITCHELL CONSTRUCTION DATE

STATE OF COLORADO)
) SS
COUNTY OF BOULDER)

THE FOREGOING INSTRUMENT WAS ACKNOWLEDGED BEFORE ME THIS
__________ DAY OF __________ 19______

BY ____________________

MY COMMISSION EXPIRES ____________
WITNESS MY HAND AND OFFICIAL SEAL

____
NOTARY PUBLIC

____

____
ADDRESS

DEDICATION

THE UNDERSIGNED BEING THE OWNER OF THE REAL PROPERTY LEGALLY DESCRIBED HEREON HAS CAUSED SAID REAL PROPERTY TO BE LAID OUT AS PER THE DRAWINGS HEREON CONTAINED AND SURVEYED AS ARBOR GLEN SUBDIVISION AND DOES HEREBY SET APART AND DEDICATE TO THE CITY OF BOULDER THAT PORTION OF SAID REAL PROPERTY DESIGNATED FOR STREETS, ROADS, AND AVENUES AND DRIVES AS SHOWN ON THE ACCOMPANYING PLAT FOR THE PUBLIC USE THEREOF FOREVER AND DO FURTHER DEDICATE TO THE CITY OF BOULDER FOR THEIR USE AND THE USE OF ALL MUNICIPALLY OWNED, PERMITTED, AND/OR MUNICIPALLY FRANCHISED UTILITIES AND SERVICES THOSE PORTIONS OF SAID REAL PROPERTY WHICH ARE SO DESIGNATED AS EASEMENTS AND RIGHTS-OF-WAY FOR THE CONSTRUCTION, INSTALLATION, OPERATION, MAINTENANCE, REPAIR, AND REPLACEMENT FOR ALL SERVICES, INCLUDING WITHOUT LIMITING THE GENERALITY OF THE FOREGOING, TELEPHONE AND ELECTRIC LINES, WORKS, POLES, AND UNDERGROUND CABLES, GAS PIPELINES, WATER PIPELINES, SANITARY SEWER LINES, STREET LIGHTS, CULVERTS, HYDRANTS, DRAINAGE DITCHES AND DRAINS AND ALL APPURTENANCES THEREOF, IT BEING EXPRESSLY UNDERSTOOD AND AGREED BY THE UNDERSIGNED THAT ALL EXPENSES AND COSTS INVOLVED IN CONSTRUCTING AND INSTALLING SANITARY SEWER WORKS AND LINES, GAS SERVICE LINES, ELECTRICAL SERVICE WORKS AND LINES, STORM SEWERS AND DRAINS, STREET LIGHTING, GRADING AND LANDSCAPING, CURBS, GUTTERS, STREET PAVEMENT, SIDEWALKS AND OTHER SUCH UTILITIES AND SERVICES SHALL BE GUARANTEED AND PAID FOR BY THE SUBDIVIDER OR ARRANGEMENTS MADE BY THE SUBDIVIDER THEREFORE WHICH ARE APPROVED BY THE CITY OF BOULDER, AND SUCH SUMS SHALL NOT BE PAID BY THE CITY OF BOULDER, COLORADO, AND THAT ANY ITEM SO CONSTRUCTED OR INSTALLED WHEN ACCEPTED BY THE CITY OF BOULDER, EXCEPT ITEMS OWNED BY MUNICIPALLY FRANCHISED UTILITIES WHICH ITEMS, WHEN CONSTRUCTED OR INSTALLED, SHALL REMAIN THE PROPERTY OF THE CITY

APPROVED

____
PUBLIC SERVICE COMPANY
OF COLORADO

____
CITY OF BOULDER — DIRECTOR OF
PUBLIC WORKS/PUBLIC UTILITIES

____
MOUNTAIN STATES TELEPHONE

____
CITY OF BOULDER — DIRECTOR OF
PLANNING AND COMMUNITY DEVELOPMENT

____
CITY OF BOULDER — DIRECTOR OF
REAL ESTATE/OPEN SPACE

SURVEYOR'S CERTIFICATE

I, ROBERT ORTHMAN DO HEREBY CERTIFY THAT THE SURVEY OF THE BOUNDARY OF ARBOR GLEN SUBDIVISION WAS MADE UNDER MY SUPERVISION AND THE ACCOMPANYING PLAT ACCURATELY REPRESENTS SAID SURVEY, AND THAT I HAVE COMPLIED IN ALL RESPECTS WITH COLORADO REVISED STATUTES, CHAPTER 51, ARTICLE 2, (1963 AS AMENDED IN 1967)

____________________ NO 15315
REGISTERED LAND SURVEYOR

BASIS OF BEARING

BEARING BASED ON WEST LINE OF THE SOUTHWEST ¼ of SECTION 17, T 1 N, R 70 W, 6 TH PM AS BEARING S 00°12'00" E

CLERK AND RECORDER'S CERTIFICATE

STATE OF COLORADO)
) SS
COUNTY OF BOULDER)

I HEREBY CERTIFY THAT THIS PLAT WAS FILED IN MY OFFICE AT _____ O'CLOCK ____M, ON THE _______ DAY OF ____________ 19____ AND IS DULY RECORDED IN PLAN FILE ____________ FEES PAID __________

____
RECORDER

LENDER'S APPROVAL

____

____
BANK OF BOULDER

BY ____________________

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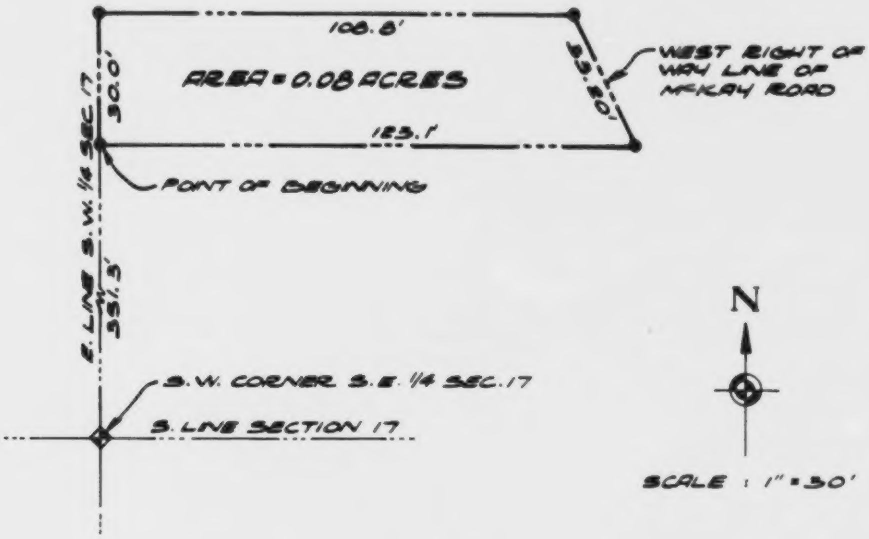
Student Supplement 4—Example of a Legal Description


108.8'
AREA = 0.08 ACRES
30.0'
33.20'
WEST RIGHT OF WAY LINE OF McKAY ROAD
123.1'
POINT OF BEGINNING
E. LINE S.W. 1/4 SEC. 17
351.3'
S.W. CORNER S.E. 1/4 SEC. 17
S. LINE SECTION 17
N
SCALE : 1" = 30'

LEGAL DESCRIPTION:

That part of the Southwest one-quarter of the Southeast one-quarter of Section 17, Township 2 South, Range 67 West of the 6th P.M., County of Adams, State of Colorado, more particularly described as follows:

Commencing at the Southwest corner of the Southeast one-quarter of said Section 17, thence North a distance of 351.3 feet along the East line of the Southwest one-quarter of Section 17, to the point of true beginning; Thence East 123.1 feet more or less, along a line parallel to the South line of Section 17, to the county road; Thence Northwesterly along the right-of-way line of the county road a distance of 33.2 feet more or less; Thence West a distance of 108.8 feet more or less, along a line parallel to the South line of Section 17, to the county road; Thence South a distance of 30.0 feet to the point of beginning, containing 0.08 acres, more or less.

PROPOSED CONSTRUCTION EASEMENT for
SOUTH ADAMS COUNTY
WASTEWATER TREATMENT PLANT

CONSULTING ENGINEERS **SELLARDS & GRIGG, Inc.**
LAKEWOOD, COLORADO

PROJECT 77016-41 JUNE, 1978 D.F.L.

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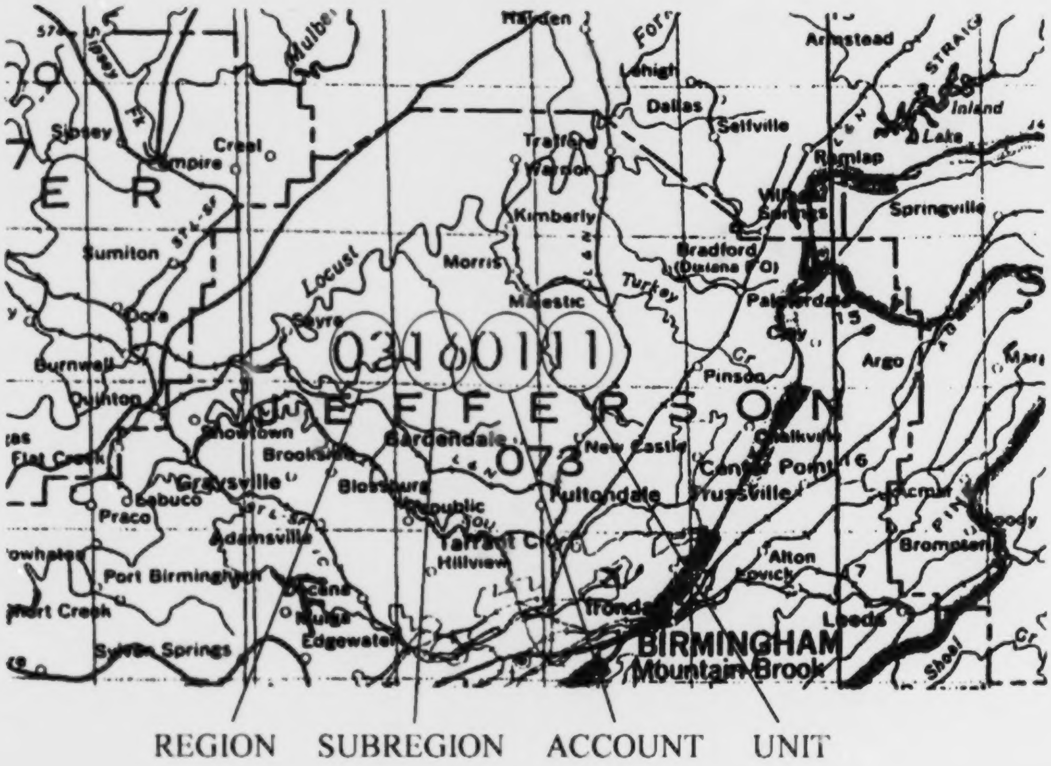
Student Supplement 5—Example of a Hydrologic Unit Map


03160111
JEFFERSON
073
REGION
SUBREGION
ACCOUNT
UNIT
Sumiton
Empire
Sipsey
Dora
Burnwell
Quinton
Graysville
Adamsville
Port Birmingham
Sylvan Springs
Edgewater
Brookside
Bloosburg
Gardendale
Tarrant City
Hillview
Morris
Majestic
Kimberly
Warrior
Trafford
Hayden
Dallas
Lehigh
Selfville
Bradford
Pinson
New Castle
Fultondale
Center Point
Trussville
Chalkville
Argo
Springville
Armstead
Inland Lake
Remlap
Alton
Leeds
Brompton
Acmar
Irondale
BIRMINGHAM
Mountain Brook
Locust
Turkey
Praco
Sayre
Flat Creek

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Objective 34

Assignment Sheet 1—Lay Out a Boundary Survey From a Legal Description

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Boundaries close to within .065 accuracy	______
• Assignment is appropriately labeled and documented	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics Critical Thinking

Directions

You will be given a written legal description from which you will lay out the boundary survey. Study the following example prior to beginning your assigned problem.

Example

Facts: The southwesterly line of this Lot 15 is 235.00 feet (77.10m) long and is also on the northeasterly line of Wood Street and bears S 68° 00' E. The northwesterly line of this lot is 184.00 feet (60.37m) long and bears N 35° 00' E. The southeasterly line of the lot is 216.00 feet (70.87m) long and bears S 20° 00' W. The lot will draft onto a letterhead size sheet using a 1" = 30' scale.

Description: That portion of Lot 15 of Fred Macrae's Tract in Calcasieu Parish, Louisiana, as per map filed in the office of Public Records described by the following courses:

1—Beginning at a point on the northeast line of Wood Street S 68°00' E 22.40 feet (7.35m) from the most westerly corner of said Lot,
2—N 63°20' E 38.50 feet (12.63m),
3—N 24°30' E 47.42 feet (15.56m),
4—S 87°25' E 87.86 feet (28.83m),
5—N 19°20' E 35.64 feet (11.69m),
6—S 68°00' E 78.83 feet (25.86m),
7—S 24°00' W 141.15 feet (46.31m) to Wood Street,
8—N 68°00' W 182.62 feet (59.91m) along Wood Street to the point of beginning.

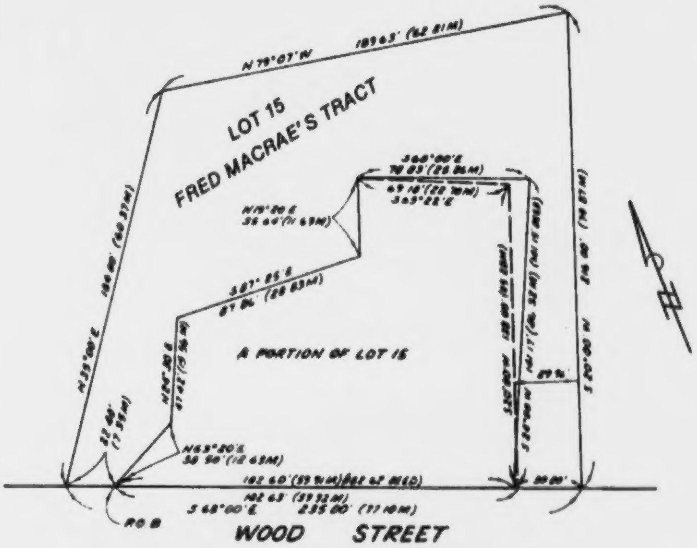
When a course ties to a point, a line or a monument, etc., that then is the controlling factor and if the tie is to a line only, then the distance must be given, while if the tie is to a point, then both the distance and bearing of the line preceding it must be given to the position of that point.

If courses 6 and 7 were changed to read:

6—S 68°00′ E 78.83 feet (25.86m) to a point on a line parallel with and 29.96 feet (9.83m) northwesterly from the southeasterly line of said Lot which point is N 20°00′ E 138.00 feet (45.28m) from the northeasterly line of Wood Street,

7—S 20°00′ W 138.00 feet (45.28m) to Wood Street, draw the additional lines necessary to show their positions with heavy dash lines.

Figure 1—Drafted Layout of Example



Directions

Take the following description and draw a map of the "Adams Property."

1. Lay out on "D" size vellum.
2. Scale: 1″= 30′.
3. Finalize with ink on polyester film.
4. Hand letter dimensions and notes.
5. Use mechanical or transfer lettering for the title information.
6. Place north arrow with scale and scale bar.
7. Place 1/2″ border all around.

Note: Refer to Unit 12 for a guide to final drafting of this map.

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Assignment Sheet 1

Adams Property Tract 1

A tract of land located in the SW 1/4 of the NW 1/4 of Section 21, T1S, R70W of the 6th P.M., County of Denver, State of Colorado, described as follows:

Commencing at the W 1/4 Corner of said Section 21, from which the Northwest Corner of said Section 21 bears N00°03′50″W, thence N62°8′10″E, 526.68 feet to the most Southerly Corner of that tract of land conveyed to Robert W. Adams and Alice C. Adams as described in Warranty Deed recorded on Film 518 as Reception No. 769196 of the records of Denver County, Colorado and the TRUE POINT OF BEGINNING;

Thence N13 °18′50″W, 323.80 feet along the Southwesterly line of that tract of land as described on said Film 518 as Reception No. 769196;

Thence N31°21′10″E, 169.74 feet along the Northwesterly line of that tract of land as described on said Film 518 as Reception No. 769196;

Thence N77°42′10″E, 148.83 feet along the Northwesterly line of that tract of land as described on said Film 518 as Reception No. 769196;

Thence S13°09′50″E, 690.46 feet to the Northwesterly right-of-way line of Colorado State Highway No. 398;

Thence S60°50′10″W, 140.00 feet along the Northwesterly right-of-way line of said Colorado State Highway No. 398 to the most Southerly Corner of that tract of land conveyed to Robert W. Adams and Alice C. Adams as described in Warranty Deed recorded on Film 598 as Reception No. 842097 of the records of Denver County, Colorado;

Thence N13°09′50″W, 324.43 feet along the Southwesterly line of that tract of land as described on said Film 598 as Reception No. 842097 to the Southeasterly line of that tract of land as described on said Film 518 as Reception No. 769196;

Thence S60°50′10″W, 137.73 feet along the Southeasterly line of that tract of land as described on said Film 518 as Reception No. 769196 to the TRUE POINT OF BEGINNING.

Area = 3.330 acres, more or less.

Objective 35

Assignment Sheet 2—Reduce Field Notes and Plot a Simple Boundary Survey

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Boundaries close to within .065 accuracy	______
• Assignment is appropriately labeled and documented	______
• Assignment is neat and legible	______

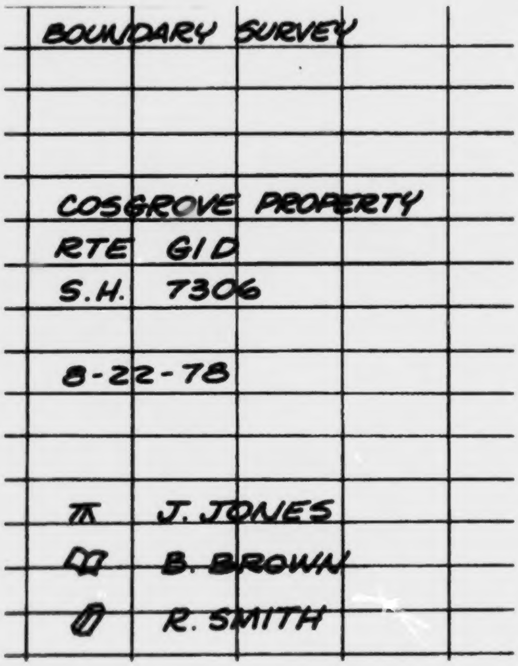
Basic Skills

Reading Mathematics Critical Thinking

Directions

Given the field service notes provided in this assignment, calculate the bearing of each property line, the coordinates for each corner, and the area of the parcel. Assume coordinates of 1,000.00, 10,000.00 for point "A". Check to make sure that the sum of the "x" and "y" coordinates on either side of the parcel are equal. Prepare a working drawing of this parcel on 22″ x 34″ reproducible paper.

Figure 1



BOUNDARY SURVEY

COSGROVE PROPERTY
RTE GID
S.H. 7306

8-22-78

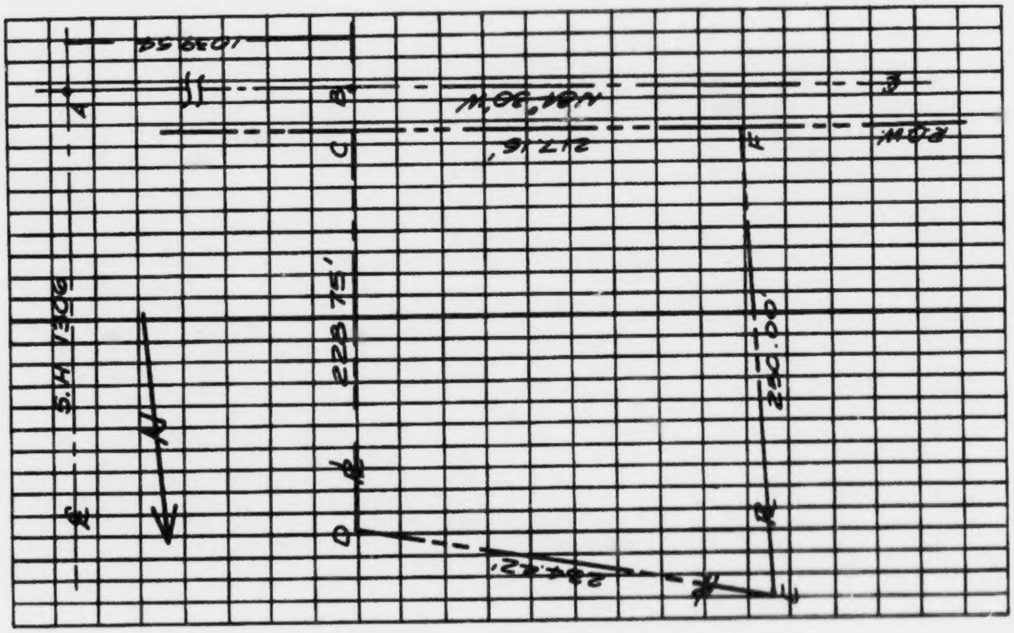
J. JONES
B. BROWN
R. SMITH

Assignment Sheet 2

Figure 2

⊼	BS	FS	∡	DIST.	NOTES
B	A	C	270°00'00"	BC 33.00'	AB 1039.54'
		D	270°00'00"	CD 228.75'	
D	B	E	95°04'10"	DE 234.92'	
E	D	F	81°10'50"	EF 250.00'	
F	E	C	93°45'00"	FC 217.15'	
C	F	D	90°00'00"		

Figure 3


1039.54'
A
B
C
D
E
F
N84°30'W
217.15'
ROW
S.H. 1306
N
228.75'
250.00'
234.92'

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800

Objective 36

Assignment Sheet 3—Develop From Field Notes the Plat Map for a Nine-Lot Subdivision

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Boundaries close to within .065 accuracy	______
• Plat map is labeled correctly	______
• Map includes all necessary documentation	______
• Area is correctly tabulated	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics Critical Thinking

Directions

Part 1

Use the attached field notes to each of the nine lots plus road to center line to develop a partial subdivision plat. Follow the guidelines given below:

1. Use a 17" x 22" sheet of vellum.
2. Lay out the 9 lots of the "Last Chance" subdivision at a scale of 1 " = 50'.
3. Complete the map with all necessary peripheral information.

Part 2

Planimeter the finished map as outlined in Job Sheet 1 of Unit 12. Determine the areas for each individual lot and the total area to the centerline of the roads. Compare your figures obtained with the planimeter to the calculated acres in the field notes. Set up a chart on "A" size vellum with the following information: lots, areas, total areas of lots, and total areas to centerline. Hand letter the chart in pencil or ink.

STA	LENGTH (FT)	BEARING	RAW	LAT	RAW	DEP	ADJ	LAT	ADJ	DEP	COORD	
			+N	-S	+E	-W	+N	-S	+E	-W	X	Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOT 1						DMD	2 AREA				
	32.39	S45°03'00"W	-22.88		-22.92		-22.92	+524.41			-22.92	-22.88
	270.18	S44°58'30"E	-191.13		+190.96		+145.12	-27736.79			+168.04	-214.01
	339.28	N62°27'00"E	+156.92		+300.81		+636.89	+99940.78			+468.85	-57.09
	455.82	N77°10'00"W	+101.24		-444.43		+493.27	+49938.65			+24.42	+44.15
	50.454	S28°56'51"W	-44.15		-24.42		+24.42	-1078.14			0	0
			-258.16	+258.16	-491.77	+491.77	2 AREA = 121588.91 SQ.FT.					
	COORDINATES						AREA = 60794.455 SQ FT. = 1. 3956486 ACRES					
TOTALS		DIFF										

COORDINATES

-22.92 (-214.01-0) = +4905.11

168.04 (-57.09+22.88) = -5748.55

468.85 (44.15+214.01) = +121038.31

24.42 (0+57.09) = +1394.14

2 AREAS = 121588.91 SQ.FT.

AREA = 60794.45 SQ FT. = 1.3956 ACRES (MINUS CURB EXCESS = 120.48 SQ.FT.)

Assignment Sheet 3

STA	LENGTH (FT)	BEARING	RAW LAT		RAW DEP		ADJ LAT		ADJ DEP		COORD	
			+N	-S	+E	-W	+N	-S	+E	-W	X	Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+	0	0
	LOT 2						DMD		2 AREA			
	148.81	N62°27'00"E	+68.83		+131.94		+131.94		+9081.43		+68.83	+131.94
	270.18	N44°58'30"W	+191.13		-190.96		+72.92		+13937.20		+259.96	-59.02
	163.81	S45°03'00"W	-115.73		-115.93		-233.97		+27077.35		+144.23	-174.95
	226.75	S50°30'00"E	-144.23		+174.97		-174.93		+25230.15		0	0.02
			+259.96	-259.96	+306.91,	-306.89	2 AREA = 75326.13					
					+0.02		AREA = 37663.065 SQ. FT = 0.864625 ACRES					
	COORDINATES											
	2 AREA = 0(68.83.-144.23) =				0							
	131.94(259.96-0)				= +34299.122							
	-59.02(144.23-68.83)				= -4450.108							
	-174.95(0-259.96)				= 45480.002							
			2 AREA		= 75329.016							
			AREA		= 37664.508 SQ.FT. = 0.8646581 ACRES							
TOTALS		DIFF										

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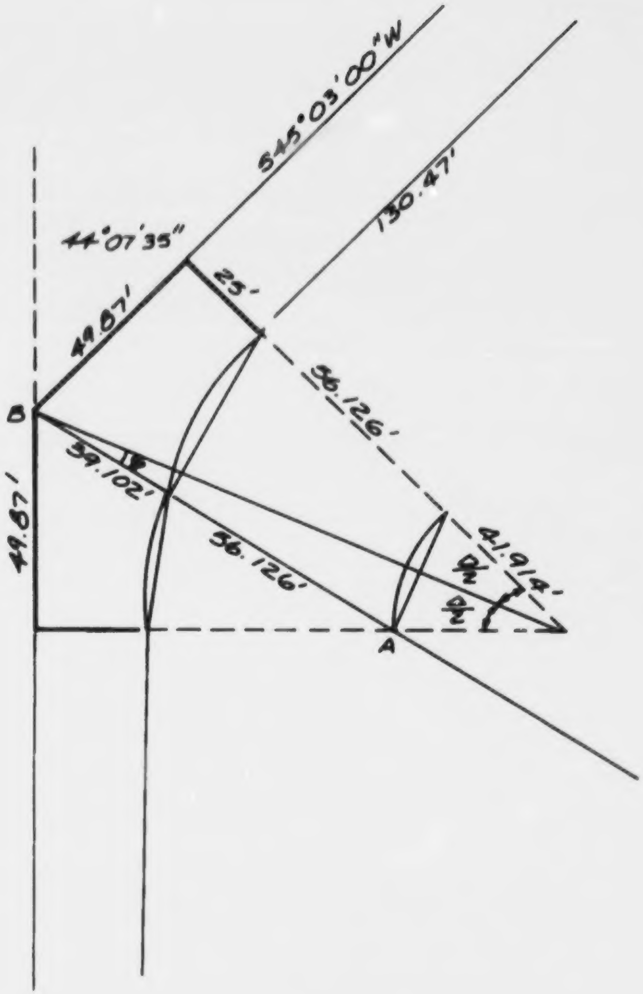
Assignment Sheet 3

STA	LENGTH (FT)	BEARING	RAW	LAT	RAW	DEP	ADJ	LAT	ADJ	DEP	COORD	
			+N	-S	+E	-W	+N	-S	+E	-W	X	Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOT 3						DMD	2 AREA				
	170.88	S 57°29'47"E	-91.82		+144.11		+144.11	-13232.18			+144.11	-91.82
	165.02	N62°27'00"E	+76.33		+146.31		+434.53	+33167.67			+290.42	-15.49
	226.75	N50°30'00"W	+144.23		-174.97		+405.87	+58538.63			+115.45	+128.74
	130.47	S45°03'00"W	-92.18		-92.34		+138.56	-12772.46			+23.11	+36.56
	43.25	S 32°17'51"W	-36.56		-23.11		23.11	-844.90			0	0
			220.56	+220.56	-290.42	+290.42	2 AREA = 64856.76					
	COORDINATES						AREA = 32428.38 SQ. FT. = 0.7444531 ACRES					
	144.11(-15.49-0) =		-2232.26				0.744 ACRES + CURVE (70.02 SQ.FT.)					
	290.42(128.74+91.82) =		+64055.04				0.746 ACRES					
	115.45(36.56+15.49) =		+6009.17									
	23.11(0-128.74) =		-2975.18									
		2 AREA =	64856.768									
		AREA =	32428.384 SQ. FT. = 0.7444532 ACRES									
TOTALS		DIFF										


S45°03'00"W
130.47'
44°07'35"
25'
49.87'
56.126'
B
39.102'
β
49.87'
56.126'
41.914'
Δ/2
Δ/2
A

$\beta = 9.51681°$

$\frac{\Delta}{2} = 22.063194°$

$\alpha = 148.42°$

BISECTOR = 132.762'

$$\text{SHORT CHORD} = \frac{\sin 44°07'35''}{SC} = \frac{\sin 67.93681°}{41.914'}$$

$SC = 31.488'$

$\frac{1}{2}\ SC = 15.744'$

LOT 3

CURVE DATA

STA	LENGTH (FT)	BEARING	RAW +N	LAT −S	RAW +E	DEP −W	ADJ +N	LAT −S	ADJ +E	DEP −W	COORD X	COORD Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOT 4						DMD	2 AREA				
	244.78	S00°55'25"W	-224.75		-3.62		-3.62	+813.60			-3.62	-224.75
	151.31	S89°01'30"E	-2.57		+151.29		+144.05	-370.21			+147.67	-227.32
	166.78	N00°43'00"E	+166.77		+2.09		+297.43	+49602.40			+149.76	-60.55
	170.88	N57°29'47"W	+91.82		-144.11		+155.41	+14269.75			+5.65	+31.27
	31.776	S10°14'31"W	-31.27		-5.65		+5.65	-176.68			0	0
		-	258.59	+258.59	-153.38	+153.38	2 AREA = 64138.86 SQ.FT.					
							AREA = 32069.43 SQ.FT. = 0.7362128 ACRES					
TOTALS		DIFF										

COORDINATES

-362(-227.32-0) = + 822.90

147.67(-60.55+224.75) = +24247.41

149.76(31.27+227.32) = +38726.44

5.65(0+60.55) = + 342.11

2 AREA = 64138.857 SQ.FT.

AREA = 32069.428 SQ.FT. = 0.7362127 ACRES (MINUS SE CORNER CURB-AREA = 100.09 SQ.FT. PLUS CORNER AREA A Δ 44°07'35" = +43.20 SQ.FT. -56.89 SQ.FT.

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Assignment Sheet 3

STA	LENGTH (FT)	BEARING	RAW LAT +N	RAW LAT −S	RAW DEP +E	RAW DEP −W	ADJ LAT +N	ADJ LAT −S	ADJ DEP +E	ADJ DEP −W	COORD X	COORD Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOT 5						DMD	2AREA				
	155.30	S89°01'30"E	-2.64		+155.28		+155.28	-409.94			+155.28	-2.64
	245.43	N01°36'30W	+245.33		-6.89		+303.67	+74499.36			+148.39	+242.69
	165.02	S62°27'00"W	-76.33		-146.31		+150.47	-11485.38			+2.08	+166.56
	166.78	S00°43'00"W	-166.77		-2.09		+2.07	-345.21			-0.01	-0.41
			-245.74,	+245.33	-155.29,	155.28	2 AREA = 62258.827 SQ. FT.					
							AREA = 31129.413 SQ. FT. = 0.7146329 ACRES					
TOTALS		DIFF										

COORDINATES

155.28 (242.69-0) = +37684.90

148.39 (166.36+2.64) = +25077.91

2.08(-0.41-242.69) = -505.65

-0.01(0-166.36) = + 1.66

2 AREA = 62258.823 SQ. FT.

AREA = 31129.411 SQ. FT = 0.7146329 ACRES

812

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813

Assignment Sheet 3

STA	LENGTH (FT)	BEARING	RAW LAT +N	RAW LAT −S	RAW DEP +E	RAW DEP −W	ADJ LAT +N	ADJ LAT −S	ADJ DEP +E	ADJ DEP −W	COORD X	COORD Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOT 6						DMD	2AREA				
	152.78	S89°01'30"E	-2.60		+152.76		+152.76	-397.18			+152.76	-2.60
	317.97	N05°00'00"W	+316.76		-27.71		+277.81	+87999.10			125.05	314.16
	148.81	S62°27'00"W	-68.83		-131.94		+118.16	-8162.95			-6.89	245.33
	245.43	S01°36'30"E	-245.33		+6.89		-6.89	1690.32			0	0
			-316.76,	+316.76	-159.64,	159.65	2 AREA = 81159.29					
							AREA = 40579.645 SQ.FT. = 0.9315804 ACRES					
TOTALS		DIFF										

COORDINATES

152.76 (314.16 − 0) = +47991.08
125.05 (245.33 + 2.60) = +31003.65
−6.89 (0 − 314.16) = +2164.56
0(−2.60 − 245.33) = 0
2 AREA = 81159.29
AREA = 40579.645 SQ.FT. = 0.9315804 ACRES

Assignment Sheet 3

STA	LENGTH (FT)	BEARING	RAW LAT +N	RAW LAT − S	RAW DEP + E	RAW DEP − W	ADJ LAT + N	ADJ LAT − S	ADJ DEP + E	ADJ DEP − W	COORD X	COORD Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOT 7						DMD	2AREA				
	148.42	S89°01'30"E	-2.53		+148.40		+148.40	-375.45			+148.40	-2.53
	374.42	N14°21'30"W	+362.72		-92.85		+203.95	+73976.74			+55.55	360.19
	93.91	S62°27'00"W	-43.44		-83.26		+27.84	-1209.37			-27.71	316.75
	317.97	S05°00'00"E	-316.76		+27.71		-27.71	8777.42			0	-0.01
			-362.73,	+362.72	-176.11,	+176.11	2 AREA = 81169.34					
							AREA = 40584.67 SQ.FT.=0.9316958 ACRES					
TOTALS		DIFF										

COORDINATES

148.40(360.19 + .01) = + 53453.68

55.55(316.75+2.53) = + 17736.00

-27.71(-.01-360.19) = + 9981.14

0(-2.53-316.75) = 0

2 AREA = 81170.82

AREA = 40585.41 SQ.FT. = 0.9317128 ACRES

STA	LENGTH (FT)	BEARING	RAW LAT +N	RAW LAT −S	RAW DEP +E	RAW DEP −W	ADJ LAT +N	ADJ LAT −S	ADJ DEP +E	ADJ DEP −W	COORD X	COORD Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOT 8						DMD	2AREA				
	40.61	S89°01'30"E	-0.69		+40.60		+40.60	-28.014			40.60	-0.69
	152.58	N35°06'30"E	+124.82		+87.75		+168.95	+21088.339			128.35	124.13
	314.01	N25°45'30"W	+282.81		-136.46		+120.24	+34005.074			-8.11	406.94
	95.75	S62°27'00"W	-44.29		-84.89		-101.11	+4478.16			-93.00	362.65
	374.42	S14°21'30"E	-362.72		+92.85		-93.15	+33787.368			-0.15	-0.07
			+407.70	+407.63	-221.35	+221.20	2AREA = 93330.927					
	COORDINATES						AREA = 46665.463 SQ.FT. = 1.0712916 ACRES					
	40.60(124.13-0.07) = +5036.84											
	128.35(406.94+.69) = +52319.31											
	-8.11(362.65-124.13) = -1934.40						CURVE - 250.46 SQ.FT					
	-93.00(-.07-406.94) = +37851.93						CUL-DE-SAC - 741.96 SQ.FT. (APPROX)					
	-0.15(-0.69-362.65) = +54.50						992.42 SQ.FT					
		2 AREA = 93328.18 SQ.FT.										
TOTALS		AREA = 46664.09 SQ.FT. = 1.0712601 ACRES										
		DIFF										

Assignment Sheet 3

STA	LENGTH (FT)	BEARING	RAW LAT +N	RAW LAT − S	RAW DEP + E	RAW DEP − W	ADJ LAT + N	ADJ LAT − S	ADJ DEP + E	ADJ DEP − W	COORD X	COORD Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOT 9						DMD	2 AREA				
	149.56	N64°13'30"E	+ 65.03		+134.68		134.68	8758.24			65.03	134.68
	347.16	N25°45'25"W	+312.67			-150.86	118.50	37051.40			377.70	-16.18
	149.62	S62°27'00"W		-69.20		-132.65	-165.01	+11418.69			308.50	-148.83
	342.54	S25°45'30"E		-308.50	+148.86		-148.80	+45904.80			0	0
			+ 377.70	-377.70	+ 283.54	- 283.51						
					+0.03							
TOTALS												
		DIFF										

2 AREA = 11513.85
= 5756.925 SQ.FT.
1.1838 ACRES

COORDINATES
0(65.03 - 308.50) = 0
134.68(377.70 - 0) = 50868.64
-16.18(308.50 - 65.03) = -3939.34
- 148.83(0 - 377.70) = 56213.09
51571.19 SQ.FT. - 1590.43 (COL-DE-SAC) = 1.1839 ACRES

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Assignment Sheet 3

STA	LENGTH (FT)	BEARING	RAW LAT +N	RAW LAT − S	RAW DEP + E	RAW DEP − W	ADJ LAT + N	ADJ LAT − S	ADJ DEP + E	ADJ DEP − W	COORD X	COORD Y
	+	+	L COS BE	L COS BE	L SIN BE	L SIN BE	+	+	+	+		
	LOTS 1 - 9 PLUS ROAD TO CENTER LINE						DMD	2AREA				
	418.08	S45°03'00"W		-295.37		-295.88	-295.88	+87394.075			-295.88	-295.37
	299.65	S00°55'25W		-299.61		- 4.83	-596.59	+178744.32			-300.71	-594.98
	686.38	S89°01'30"E		- 11.68		+686.28	+84.86	-991.16			+385.57	-606.66
	152.58	N35°06'30"E		+124.82		+87.75	+858.89	+107206.64			+473.32	-481.84
	149.56	N64°13'30"E		+65.03		+134.68	+1081.32	+ 70318.239			+608.00	-416.81
	347.16	N25°45'25"W		+312.67		-150.86	+1065.14	+333037.32			+457.14	-104.14
	468.85	N77°10'00"W		+104.14		-457.14	+457.14	+47606.56			0	0
			-606.66	+606.66	-908.71	+908.71	2 AREA = 823315.97 AREA = 411657.98 SQ.FT. = 9.4503668 ACRES					
	-295.88(-594.98-0) + 300.71 (-606.66 + 295.37) + 385.57 (-481.84 + 594.98) + 473.32 (-416.81 + 606.66)											
TOTALS	+608.00(-140.14 + 481.84) + 457.14 (0+416.81) = +176042.68 + 93608.015 + 43623.369 + 89859.802 + 229641.6 + 190540.52 = 2 AREA = 823315.99 AREA = 411657.99 SQ.FT. = 9.450 ACRES	DIFF										

822

823

Objective 37

Assignment Sheet 4—Redraw to Scale a Complete Final Plat of a 36-Lot Subdivision

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Map layout is clear and concise	______
• Assignment is documented correctly	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Given

A copy of a complete final plat for a 36-lot division

Directions

Complete assignment on CAD. Follow the guidelines given below.

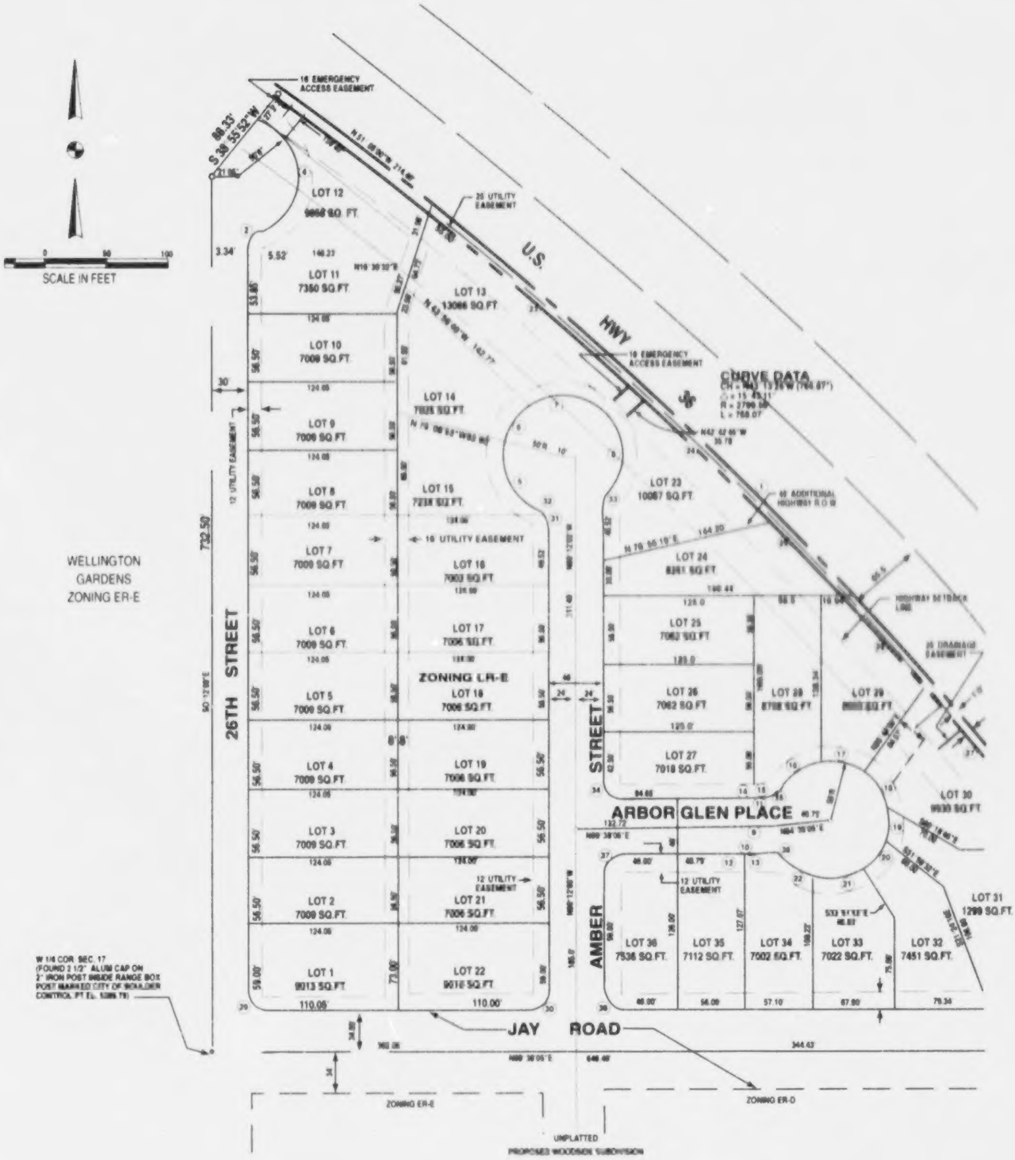
1. Use drawing scale 1″ = 50″ for plotting.
2. Lay out the boundary survey.
3. Dimension completely.
4. Include
   - Certificate information
   - Legal description
   - Dedication
5. Include all title information and bearing chart.

   Note: Refer to Unit 12 for additional information on setting up your map.

ARBOR GL

FIN

A SUBDIVISION OF A PART
OF THE 6TH P.M., COUNTY


SCALE IN FEET
0
50
100
WELLINGTON
GARDENS
ZONING ER-E
26TH STREET
U.S. HWY
AMBER STREET
ARBOR GLEN PLACE
JAY ROAD
ZONING LR-E
16 EMERGENCY ACCESS EASEMENT
25 UTILITY EASEMENT
16 UTILITY EASEMENT
12 UTILITY EASEMENT
CURVE DATA
40 ADDITIONAL HIGHWAY R.O.W.
HIGHWAY SETBACK LINE
20 DRAINAGE EASEMENT
LOT 1 9013 SQ.FT.
LOT 2 7009 SQ.FT.
LOT 3 7009 SQ.FT.
LOT 4 7009 SQ.FT.
LOT 5 7009 SQ.FT.
LOT 6 7009 SQ.FT.
LOT 7 7009 SQ.FT.
LOT 8 7009 SQ.FT.
LOT 9 7009 SQ.FT.
LOT 10 7009 SQ.FT.
LOT 11 7350 SQ.FT.
LOT 12
LOT 13 13086 SQ.FT.
LOT 14
LOT 15
LOT 16 7002 SQ.FT.
LOT 17 7006 SQ.FT.
LOT 18 7006 SQ.FT.
LOT 19 7006 SQ.FT.
LOT 20 7006 SQ.FT.
LOT 21 7006 SQ.FT.
LOT 22 9010 SQ.FT.
LOT 23 10067 SQ.FT.
LOT 24
LOT 25 7062 SQ.FT.
LOT 26 7062 SQ.FT.
LOT 27 7018 SQ.FT.
LOT 28
LOT 29
LOT 30
LOT 31
LOT 32 7451 SQ.FT.
LOT 33 7022 SQ.FT.
LOT 34 7002 SQ.FT.
LOT 35 7112 SQ.FT.
LOT 36 7536 SQ.FT.
732.50
110.06'
110.00'
W 1/4 COR. SEC. 17 (FOUND 2 1/2" ALUM CAP ON 2" IRON POST INSIDE RANGE BOX POST MARKED CITY OF BOULDER CONTROL PT EL. 5286.79)
ZONING ER-E
ZONING ER-D
UNPLATTED
PROPOSED WOODSIDE SUBDIVISION

EN SUBDIVISION

AL PLAT

OF SECTION 17, T.IN., R. 70 W
OF BOULDER, STATE OF COLORADO

LENDER'S APPROVAL

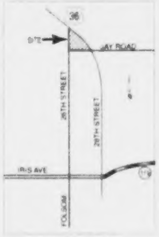
____

____

BANK OF BOULDER
BY: ______________________

DEDICATION

THE UNDERSIGNED BEING THE OWNER OF THE REAL PROPERTY LEGALLY DESCRIBED HEREON HAS CAUSED SAID REAL PROPERTY TO BE LAID OUT AS PER THE DRAWINGS HERE ON CONTAINED AND SURVEYED AS ARBOR GLEN SUBDIVISION AND DOES HEREBY SET APART AND DEDICATE TO THE CITY OF BOULDER THAT PORTION OF SAID REAL PROPERTY DESIGNATED FOR STREETS, ROADS AND AVENUES AND DRIVES AS SHOWN ON THE ACCOMPANYING PLAT FOR THE PUBLIC USE THEREOF FOREVER AND DO FURTHER DEDICATE TO THE CITY OF BOULDER FOR THEIR USE AND THE USE OF ALL MUNICIPALLY OWNED, PERMITTED AND/OR MUNICIPALLY FRANCHISED UTILITIES AND SERVICES THOSE PORTIONS OF SAID REAL PROPERTY WHICH ARE SO DESIGNATED AS EASEMENTS AND RIGHTS-OF-WAYS FOR THE CONSTRUCTION, INSTALLATION, OPERATION, MAINTENANCE, REPAIR AND REPLACEMENT FOR ALL SERVICES, INCLUDING WITHOUT LIMITING THE GENERALITY OF THE FOREGOING, TELEPHONE AND ELECTRIC LINES, WORKS, POLES AND UNDERGROUND CABLES, GAS PIPELINES, WATER PIPELINES, SANITARY SEWER LINES, STREET LIGHTS, CULVERTS, HYDRANTS, DRAINAGE DITCHES AND DRAINS AND ALL APPURTENANCES THERETO. IT BEING EXPRESSLY UNDERSTOOD AND AGREED BY THE UNDERSIGNED THAT ALL EXPENSES AND COSTS INVOLVED IN CONSTRUCTING AND INSTALLING SANITARY SEWER SYSTEM WORKS AND LINES, GAS SERVICES LINES, ELECTRICAL SERVICE WORKS AND LINES, STORM SEWERS AND DRAINS , STREET LIGHTING, GRADING AND LANDSCAPING, CURBS, GUTTERS, STREET PAVEMENT SIDEWALKS AND OTHER SUCH UTILITIES AND SERVICES SHALL BE GUARANTEED AND PAID FOR BY THE SUBDIVIDER OR ARRANGEMENTS MADE BY THE SUBDIVIDER THEREFORE WHICH ARE APPROVED BY THE CITY OF BOULDER, COLORADO, AND THAT ANY ITEM SO CONSTRUCTED OR INSTALLED WHEN ACCEPTED BY THE CITY OF BOULDER, COLORADO, SHALL BECOME PERMITTED OR THE SOLE PROPERTY OF SAID CITY EXCEPT ITEMS OWNED BY MUNICIPALLY FRANCHISED UTILITIES WHICH ITEMS, WHEN CONSTRUCTED OR INSTALLED, SHALL REMAIN THE PROPERTY OF THE CITY



VICINITY MAP
1" = 2000'

MAYOR'S CERTIFICATE

THIS IS TO CERTIFY THAT THE CITY OF BOULDER, COLORADO ADOPTS AND APPROVES THE WITHIN PLAT AND ACCEPT THE DEDICATIONS HEREON MADE.

____
MAYOR

ATTEST ________________________
DIRECTOR OF FINANCE AND RECORD
EX-OFFICIO CITY CLERK

OWNER'S SIGNATURE

FOR APPROVAL OF ARBOR GLEN SUBDIVISION AND CONDITIONS WHICH APPLY THERE TO

BY ________________________ ________________
M.L. MITCHELL CONSTRUCTION COMPANY, OWNER DATE

STATE OF COLORADO }
COUNTY OF BOULDER } S.S.

THE FOREGOING INSTRUMENT WAS ACKNOWLEDGED BEFORE ME THIS ____________ DAY OF ____________, 20____19

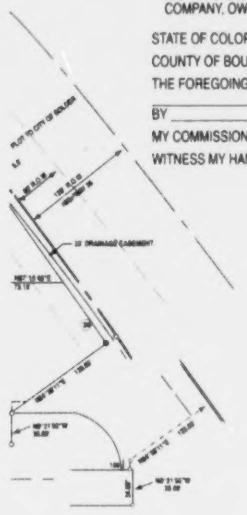
BY ________________________

MY COMMISSION EXPIRES ________________________

WITNESS MY HAND AND OFFICIAL SEAL

____
NOTARY PUBLIC

____
ADDRESS



APPROVED:

PUBLIC SERVICE COMPANY OF COLORADO	CITY OF BOULDER-DIRECTOR OF PUBLIC WORKS/PUBLIC UTILITIES
MOUNTAIN STATES TELEPHONE	CITY OF BOULDER - DIRECOTR OF PLANNING AND COMMUNITY DEVELOPMENT
CITY OF BOULDER - DIRECTOR OF REAL ESTATE/OPEN SPACE	

SURVEYOR'S CERTIFICATE

I, ROBERT ORTHMAN , DO HEREBY CERTIFY THAT THE SURVEY OF THE BOUNDARY OF ARBOR GLEN SUBDIVISION WAS MADE UNDER MY SUPERVISION AND THE ACCOMPANYING PLAT ACCURATELY REPRESENTS SAID SURVEY, AND THAT I HAVE COMPLIED IN ALL RESPECTS WITH COLORADO REVISED STATUTES, CHAPTER 51, ARTICLE 2, (1963 AS AMENDED IN 1967).

____
REGISTERED LAND SURVEYOR
NO. ____________

BASIS OF BEARING

BEARING BASED ON WEST LINE OF THE SOUTHWEST 1/4 OF SECTION 17,T.IN, R 70 W, 6TH. P.M. AS BEARING S 00° 12'00"E

CLERK AND RECORDER'S CERTIFICATE

STATE OF COLORADO }
COUNTY OF BOULDER } S.S.

I HEREBY CERTIFY THAT THIS PLAT WAS FILED IN MY OFFICE AT _____ O'CLOCK ____ M. ON THE _______ DAY OF ____________, 19 _____ AND IS DULY RECORDED IN PLAN FILE __________________, FEES PAID ____________

____
RECORDER

LEGAL DESCRIPTION ________________

A part of the Southwest Quarter of the Northwest Quarter of Section 17, Township 1 North, Range 70 West, 6th Principle Meridian, described as follows

BEGINNING AT THE WEST QUARTER CORNER OF SAID SECTION 17
Thence N 89°38'05"E, a distance of 646.48 feet.
Thence N 0°21'55"W, a distance of 35.00 feet.
Thence N 54°38'11"E, a distance of 120.03 feet.
Thence Northwesterly, 768.07 feet along the arc of a curve to the left, said curve having a radius of 2799.50 feet, a delta angle of 15° 43' 11", and being subtented by a chord that bears N 43° 13' 25" W, 765.67 feet.
Thence N 51°05'00"W, a distance of 214.40 feet.
Thence S 38°55'52"W, a distance of 88.33 feet.
Thence S 0°12'00"E, a distance of 732.50 feet,
to the POINT OF BEGINNING.

Area = 8.54 acres more or less.

NOTES
1 ○ PINS SET BY DREXEL BARRELL AND CO L.S. 17664

2 SITE IS NOT WITHIN 100 YEAR FLOOD PLAIN FOR FOURMILE CREEK
3 ● PINS SET BY ROBERT ORTHMAN L. S. 15315

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Assignment Sheet 4

NO.	CHORD	Δ	R	L	E	T
1	N 43°13′25″ W (765.67)	15°43′11″	2799.5	768.07	26.55	386.46
2	N 34°12′38″ E (15.89)	69°09′05″	14.0	16.90	3.00	9.65
3	— —	—	—	—	—	—
4	N 00°38′55″ W (93.63)	138°52′09″	50.0	121.19	92.34	133.27
5	N 24°42′06″ W (63.68)	79°06′28″	50.0	69.03	14.85	41.30
6	N 32°02′28″ E (29.55)	34°22′39″	50.0	30.00	2.34	15.47
7	S 77°36′15″ E (80.04)	106°19′56″	50.0	92.79	33.40	66.75
8	S 8°23′09″ W (54.21)	65°38′53″	50.0	57.29	9.50	32.25
9	N 87°08′05″ E (30.53)	5°00′00″	350.0	30.54	0.33	15.28
10	N 87°15′58″ E (30.91)	4°44′13″	374.0	30.92	0.32	15.47
11	N 87°17′51″ E (26.59)	4°40′27″	326.0	26.59	0.27	13.30
12	N 89°04′55″ E (7.21)	1°06′17″	374.0	7.21	0.02	3.61
13	N 86°42′50″ E (23.71)	3°37′56″	374.0	23.71	0.19	11.86
14	N 88°11′50″ E (16.36)	2°52′29″	326.0	16.36	0.10	8.18
15	N 85°51′36″ E (10.24)	1°47′58″	326.0	10.24	0.04	5.12
16	N 56°16′11″ E (42.59)	50°24′42″	50.0	43.99	5.26	23.53
17	S 76°23′41″ E (37.67)	44°15′34″	50.0	38.62	3.98	20.33
18	S 33°07′57″ E (36.05)	42°15′54″	50.0	36.88	3.60	19.33
19	S 5°17′01″ W (29.71)	34°34′04″	50.0	30.17	2.36	15.56
20	S 39°51′05″ W (29.71)	34°34′04″	50.0	30.17	2.36	15.56
21	S 82°34′51″ W (42.97)	50°53′29″	50.0	44.41	5.37	23.79
22	N 56°52′43″ W (26.04)	30°11′21″	50.0	26.35	1.79	13.49
23	S 49°11′08″ E (185.43)	3°47′45″	2799.5	185.47	1.54	92.77
24	S 45°47′20″ E (146.45)	2°59′51″	2799.5	146.46	0.96	73.25
25	S 43°25′30″ E (84.49)	1°43′46″	2799.5	84.50	0.32	42.25
26	S 41°29′10″ E (105.00)	2°08′56″	2799.5	105.00	0.49	52.50
27	S 38°42′23″ E (166.61)	3°24′38″	2799.5	166.64	1.24	83.34
28	S 36°10′56″ E (80.00)	1°38′15″	2799.5	80.01	0.29	40.01
29	S 45°16′58″ E (19.77)	89°50′05″	14.0	21.95	5.77	13.96
30	N 44°43′03″ W (19.83)	90°09′55″	14.0	22.03	5.83	14.04
31	N 15°18′59″ W (7.22)	29°54′08″	14.0	7.31	0.49	3.74
32	N 47°15′42″ W (8.18)	33°59′17″	14.0	8.30	0.64	4.28
33	S 20°25′20″ W (9.94)	41°34′31″	14.0	10.16	0.97	5.31
34	S 45°16′58″ E (19.77)	89°50′05″	14.0	21.95	5.77	18.96
35	N 58°00′44″ E (12.69)	53°53′48″	14.0	13.17	1.71	7.12
36	N 58°26′36″ W (12.56)	53°19′05″	14.0	13.03	1.67	7.03
37	S 44°43′03″ W (19.83)	90°09′55″	14.0	22.03	5.83	14.04
38	S 45°16′58″ E (19.77)	89°50′05″	14.0	21.95	5.77	13.96

Objective 38

Assignment Sheet 5—Research the Plat Information for Your Property or a Property in Your Area

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Completeness and accuracy of answers	______
• Assignment is neat and legible	______

Basic Skills

Reading Writing Critical Thinking

Directions

Complete the following worksheet.

1. Determine the location of the property you want to research.
2. Locate your local Planning Commission.
3. Make an on-site visit and request to see the plat for the property you have chosen.

   Note: If you are unable to make on-site visit, ask your instructor to provide you with a copy of a plat for a property in your area.
4. Record the following information:
   a. City ______________________________
   b. County (borough or parish) ______________________
   c. State ______________________________
   d. Is the land all or part of a lot or parcel shown on the map? __________ If so, what is the lot or parcel number, letter, or name? ____________________
   e. What is the name or number of the map? ________________
   f. If the map is officially filed or recorded, what is the correct reference file no. ____________ or book ______________ and page ____________?
   g. If the land is part of the Public Lands (that is section land), what is the section number ______________, township __________, range ______________, and meridian ______________?
   h. If the land is part of a private land grant, what is the correct reference to its map or its creation by book ______________, page ____________?

Objective 39

Assignment Sheet 6—Research the Plats for Local Utilities

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Completeness of information	______
• Assignment is neat and legible	______

Basic Skills

Reading Writing Critical Thinking Technology

Directions

1. Locate the address and phone number of each of the following utilities in your area.
    a. Gas
    b. Electric
    c. Water
    d. Sewer
    e. Telephone
    f. Zoning office
    g. Assessor's office
2. Contact each one by phone or letter to find out how you can obtain a copy of the plat that shows the utilities in your area.
3. Obtain copies of these plats through visitation of the utility or through the mail. Also request a copy of the symbols each utility uses for your future reference.
4. Check out the Internet. Some local municipalities have all development information, codes, and regulations on their local web site.

Unit 9 Transportation Mapping

Unit Contents

Student Components

Student Page

Objective Sheet 9–3

Information Sheet 9–5

Student Supplements

1—Plotting a Traverse with Angles and Coordinates 9–29
2—Field Notes for a Simple Curve 9–31
3—Superelevations of a Roadway 9–33
4—Horizontal Curve 9–35
5—Vertical Curve 9–37
6—Example of a Plan and Profile 9–39
7—Example of Cross Sections 9–41
8—Areas of Cross Sections 9–43
9—Typical Title Sheet 9–45
10—Example of a Highway Detail (Traffic Signal Plan) 9–47
11—Typical Plan and Profile 9–49

Assignment Sheets

1—Lay Out Open Traverses Using Several Methods 9–51
2—Lay Out a Survey Alignment for a Road Using Bearings and Coordinates 9–57
3—Calculate the Bearing, Slope, % Grade, True Length, and Azimuth of the ℄ of a Highway 9–59
4—Develop a Plan and Profile and Cross Sections, and Determine Cut and Fill For a Road Alignment 9–61

Objective Sheet

Unit Objective

After completing this unit, the student should be able to lay out open traverses by five different methods and develop a plan and profile and cross sections, and determine cut and fill for a road alignment. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to transportation mapping with their definitions.
2. State the purpose of route surveys.
3. Select true statements concerning the fundamentals of a route survey.
4. Complete statements concerning superelevated roadways.
5. Identify elements of a horizontal circular curve.
6. Complete statements concerning mathematical formulas used for computing a horizontal curve.
7. Select true statements concerning circular curve layout by tangent offsets.
8. Complete statements concerning vertical curves.
9. Complete statements concerning plan views for route surveys.
10. Select true statements concerning characteristics of profiles for a route survey.
11. Select true statements concerning characteristics of cross sections.
12. Complete statements concerning field note reduction for a cross section.
13. Complete statements concerning plotting cross sections.
14. Distinguish among the methods used to determine areas of cross sections.
15. State the formulas for calculating earth volume.
16. Arrange in order the steps for a road construction project.
17. List drawings included in a set of highway plans.

Objective Sheet

18. Select common horizontal and vertical scales used in transportation mapping for rural and urban areas.

19. List items that appear on a typical title sheet for a set of highway plans.

20. Select true statements concerning detail sheets.

21. Complete statements concerning drafting plan views, profiles, and cross sections.

22. Lay out open traverses using several methods. (Assignment Sheet 1)

23. Lay out a survey alignment for a road using bearings and coordinates. (Assignment Sheet 2)

24. Calculate the bearing, slope, % grade, true length, and azimuth of the ℄ of a highway. (Assignment Sheet 3)

25. Develop a plan and profile and cross sections, and determine cut and fill for a road alignment. (Assignment Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Angle of repose**—The slope of cut and fill from the road expressed in feet of horizontal run to feet of vertical run

b. **Borrow pit**—A pit or bank from which material is taken for use in filling or embanking at the construction site

Note: Borrow excavation is excavation from selected areas (borrow pits) outside the right-of-way. This is necessary when the roadway excavation does not supply sufficient suitable materials for construction of the embankment.

c. **Catch slope**—Slope that connects the road base to the existing ground

d. **Central angle**—The intersection angle of a highway curve; also called the Delta (Δ) angle

e. **Course**—A line on a traverse

f. **Curve length**—The length of a highway curve from beginning to end measured along the arc

g. **Deflection angle**—In surveying an angle that veers to the right or left of a straight line, often the centerline of a highway, power line, etc.

h. **Degree of curve**—The angle of a chord (from the preceding one) that connects station points along the centerline of a highway or railroad

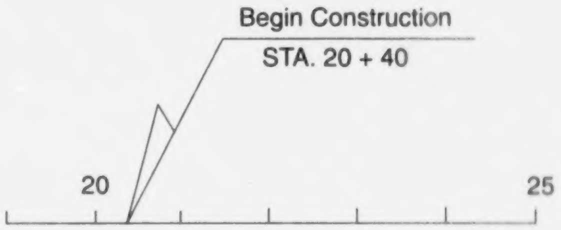
i. **Easement**—A right acquired by public authority to use or control property for a designated purpose

j. **Embankment**—Volume of material (earth) needed for roadway construction

k. **Excavation**—Volume of material excavated from roadway cross section

l. **Flag**—A large one-sided arrow used for example to indicate the beginning and end of construction

Figure 1



m. **Hub**—A substantial square stake, usually driven in flush with the ground, with a tack marking the survey point

n. **Mass diagram**—A drawing that shows the summary of earthwork over an entire project, including balance areas and quantities of earth grouped by soil classification, usually calculated by computer

o. **Match line**—The line at the edge of a mapped area which aids in fitting two drawings together

p. **Modified proctor**—Soil test that determines the optimum compaction and moisture content range of the soil

q. **Offset line**—A supplementary line close to and roughly parallel with a main line, to which it is referenced by measured offsets

r. **Point of curve**—The point at which a highway curve begins

s. **Right-of-way**—The legal right to cross the lands of another; used to indicate a strip of land provided for a road, railroad, or power line, or other linear facility

t. **Slope easement**—An easement for cut and fill

u. **Subgrade**—A portion of roadbed prepared as a foundation for the base or surface course

v. **Superelevation**—Adjusting the slope perpendicular to centerline for the purpose of counteracting centrifugal force

w. **Tangent**—Straight line of a survey

x. **Transit line**—The centerline of a linear survey (highway, pipeline, etc.)

y. **Vertical curve**—The shape of a linear feature such as a road or highway (in profile) as it crests a hill or creates a sag in a valley or depression

Objective 2

Purpose of route surveys—For making studies for the location and construction of such public utilities as highways, railways, pipelines, canals, and power lines

Objective 3

Fundamentals of a route survey

a. Conduct to obtain the following information:

- Topography
- Location of structures and objects
- Establish the survey line of the ground

b. Most common use is for highway location and construction

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c. An open traverse survey is the general method used

d. Ground configuration is obtained by running cross lines to the traverse for obtaining elevations.

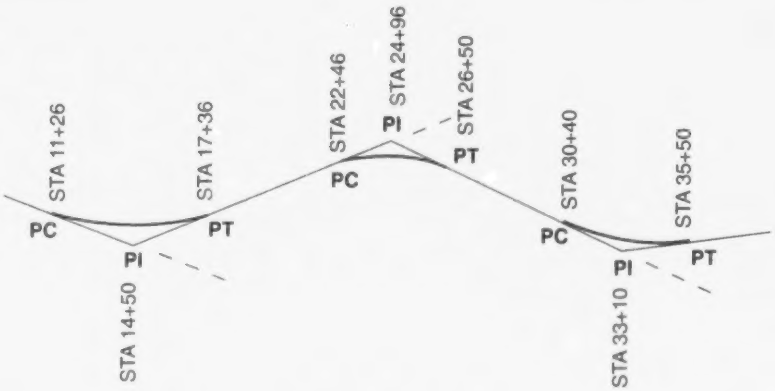
e. Open traverses can be plotted by angles or by coordinates. (Student Supplement 1)

Note: Careful checking is necessary when plotting an open traverse since there is no check for accuracy by closing the traverse.

f. Traverses are first staked out as a series of straight lines. (PI line)

g. Curves are employed at the points of change in the traverse to allow for flow of travel such as on a highway or railroad.

Figure 2



h. Spiral curves are used to make the transition from a straight line to the circular curve more gradual.

i. Route surveying normally uses transits, theodolites, or total stations. GPS is utilized for control monuments (every 300').

j. The different steps in obtaining all the necessary field data are:

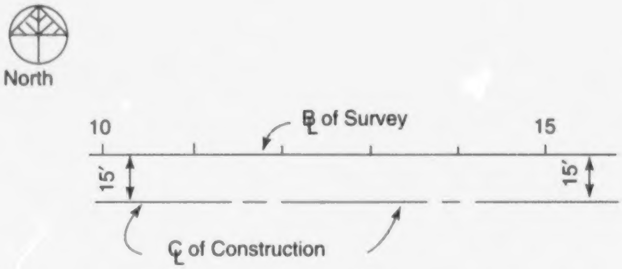
- A transit party establishes all the horizontal control. (PI lines and curves)
- The level party runs profile levels on the centerline of the survey.
- Another crew follows and runs the levels on the cross line.

k. The open traverse, complete with curves, makes up the lines for the survey alignment line.

l. The survey alignment line may not be the final construction alignment, but must be a line that can be easily worked from.

m. When the construction centerline does not coincide with the survey centerline, complete alignment data and ties to the survey centerline must be provided.

Figure 3



n. Grade line, usually the centerline of a highway, is accurately established at 100 ft. stations, at beginning and ending points of curvature, and points of intersection of the back and forward tangents.

o. Points of intersection of the grade line with storm drains, utility lines, and cross streets are also carefully marked.

p. All survey information for bearings, distances station points, and curve data must be recorded as field notes. (Student Supplement 2)

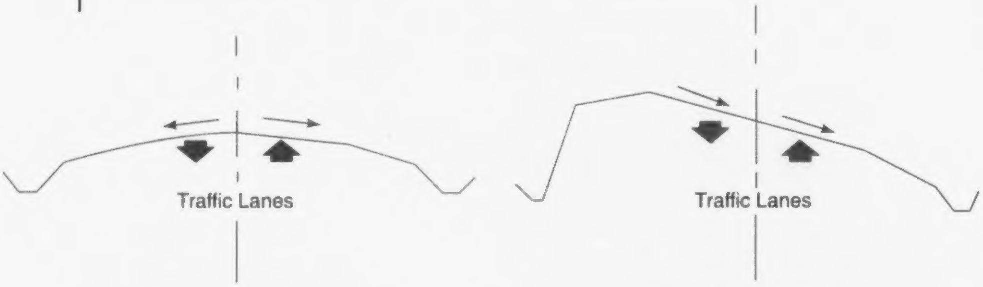
q. The field notes are then used by the drafter to construct a complete set of maps.

Objective 4

Superelevations of a roadway (Student Supplement 3)

a. A roadway is superelevated when the outside edge is higher than the inside edge; therefore, the road slopes from the outside to the inside of the curve.

Figure 4



Normal Roadway

Superelevated Roadway

From *Civil Engineering Drafting* by Roy H. and James R. Wirshing. ©1983. Reproduced with permission of Glencoe/McGraw-Hill.

b. Purpose for superelevating a roadway is to allow for easy maneuvering of vehicles through horizontal curves.

Objective 5

Elements of a horizontal circular curve (Student Supplement 4)

R — Radius of the curve

PI — Point of intersection of the two tangents to the curve

I or Δ — The central angle subtended by a curve or the change in direction of two tangents

PC — Point of curvature—The point where the tangent "A" (see Figure 5) ends and the curve begins

PT — Point of tangency—The point where the curve ends and the tangent "B" begins

L — Length of curve from the PC to the PT

T — Tangent distance—The distance from PC to PI or PI to PT

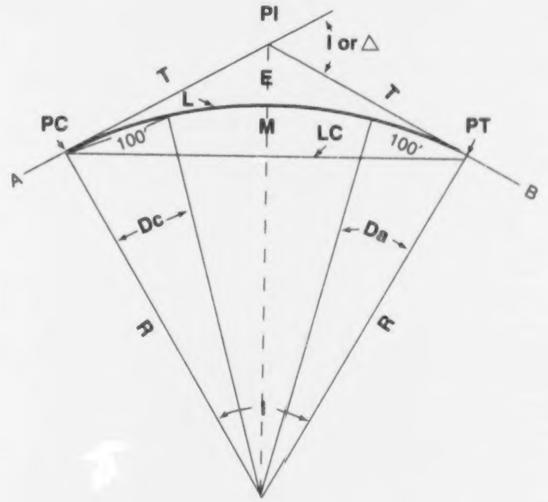
E — External distance—The distance from PI to the midpoint of the curve

LC — Long chord—The straight line distance from PC to PT

M — Middle ordinate—The distance from the midpoint of the curve to the midpoint of the long chord

D — Degree of curvature subtended by a 100′ chord (Dc) or 100′ arc (Da)

Figure 5



Objective 6

Mathematical formulas for computing horizontal curve

$$\frac{D^\circ}{360^\circ} = \frac{100}{2\pi R} \text{ and } R = \frac{5729.58}{D} \text{ ft.}$$

$$T = R \bullet \tan\frac{I}{2}$$

$$L = 100\,\frac{I}{D} \text{ or } L = \frac{I}{360}(\pi \bullet \text{Dia})$$

$$R = T/\tan\ \frac{I}{2}$$

$$LC = 2 \bullet R \sin\ \frac{I}{2}$$

$$D^\circ a = \frac{5729.58}{R} \text{ or Sin } \frac{D^\circ c}{2} = \frac{50}{R}$$

$$E = R\left(1/\cos\frac{I}{2}\right) - 1$$

$$M = R \bullet \left(1 - \cos\frac{I}{2}\right)$$

Example:

Given: Central angle $I = 38^\circ 40'$; tangent distance T = 150.0 feet.

Find:

1. Radius, R
2. Degree of curve, D
3. Length of curve, L

1. To find radius, R:

$$R = T/\tan\ \frac{I}{2}$$

$$I = 38^\circ 40', \frac{I}{2} = 19^\circ 20'$$

$$\tan 19^\circ 20' = .35085$$

$$R = \frac{150.0}{.35085} = 427.53 \text{ feet}$$

2. To find degree of curve, D:

$$\text{sine } {}^1\!/_2 D = \frac{50}{R} = \frac{50}{427.53} = .11695$$

$${}^1\!/_2 D = 6^\circ 43'$$

$$D = 13^\circ 26'$$

3. To find length of curve, L:

$$L = 100 \times \frac{38.66^\circ}{13.43^\circ} = 287.86 \text{ feet}$$

Note: The length of curve may also be found by the formula L = RI, where the angle I is in radians. This length will be slightly longer and more precise, as it represents the true arc length.

Objective 7

Circular curve layout by tangent offsets

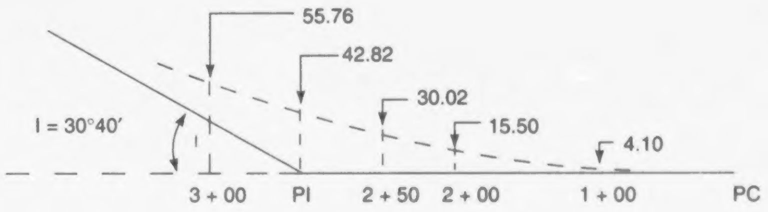
a. Used when precise layout of a curve is unnecessary.

Example: Small field ditch

b. PC, PT, and the external point are still located by transit method.

c. Tangent offsets are used to locate intermediate points on the curve.

Figure 6



Example (for Figure 6):

Given: I = 30°10′
D = 5°0′
T = 308.93
E = 40.90
L = 603.32

Solution:

Distance from PC or PT (n) stations	Offset (z) feet
0	0
1 + 00	4.37
2 + 00	17.50
2 + 50	27.34

Measure the stations from the PC and PT along the tangents toward PI and offset at right angles the distances shown in the table. (See Figure 6.) Since the tangent distance of this curve is slightly over 300 feet, the above points are adequate. Chain from the PC to determine the stationing of these stakes on the curve.

Information Sheet

Objective 8

Vertical curves—(Student Supplement 5)

a. Are the shapes of the road or highway as they crest a hill or reach the bottom of a valley.

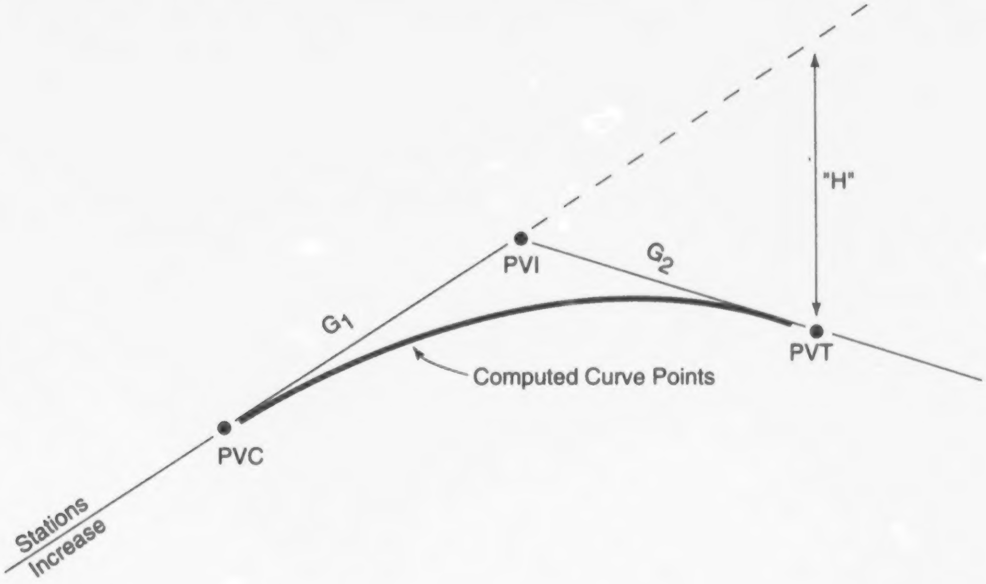
b. Are used in highway and street vertical alignment to provide a gradual change between two adjacent grade lines.

c. Are calculated and the elevation points are plotted by civil drafters.

d. The two general types are crests and sags.

e. Elements of a simple vertical curve

Figure 7



P.V.C. = Point of vertical curvature
P.V.I. = Point of vertical intersection
P.V.T. = Point of vertical tangent
G_1 = Gradient or slope of back tangent
G_2 = Gradient or slope of fore tangent
H = Vertical distance from back tangent extended to the P.V.T.

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Objective 9

Characteristics of plan views for route surveys—(Student Supplement 6)

a. Are constructed from field notes

b. Show the following:

- Contours
- Survey alignment (transit line)
- Trees
- Buildings

  Note: It is assumed all buildings will be removed from the right-of-way.
- Other roads
- Cultivated areas
- Station points
- Curve (horizontal) data
- All necessary horizontal control (bearings, distance, radii, and angles)

c. Are placed in the ungridded portion of the plan-profile paper.

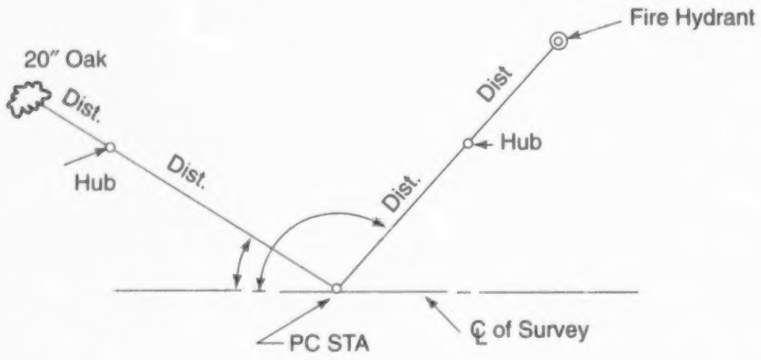
d. Sometimes many sheets of plan-profile paper are required for a route survey.

e. Each sheet contains 30 stations when the scale is 1″ = 100 feet.

f. Each sheet should begin and end with match lines.

g. Reference points (a point on tangent station) are indicated by sketches or diagrams located away from the centerline.

Figure 8



Information Sheet

Objective 10

Characteristics of profiles for a route survey

a. Profiles are drawings showing vertical sections along a certain survey line.

b. Profiles are plotted from level notes or interpolated from the contour map.

c. Level notes show elevations along the survey line.

d. Profiles are plotted on standard plan-profile paper in the gridded portion.

e. The horizontal and vertical scales are commonly not the same scale.

f. Vertical scale is exaggerated because the horizontal distances are greater as compared to the change in elevation.

g. The preferred horizontal to vertical scale ratio is 10:1.

h. Horizontal axis is the same scale as plan view.

i. Only full stations are labeled and shown as tick marks on the accented grid lines.

j. First station should be set over one grid line from the vertical scale.

k. Station numbers increase from left to right.

l. Station limits of the profile must correspond exactly to those of the plan portion of the sheet.

m. Elevations for plotting profiles are obtained from the contour map in the plan view.

n. Elevation data are indicated on both left and right sides of the sheet.

o. Even elevation numbers are placed on the inch line of the plan-profile sheet.

Objective 11

Characteristics of cross sections—(Student Supplement 7)

a. Represent a cut 90° to the profile line and are used to calculate the amount of earth to be cut or filled in a project.

b. Are usually plotted on 10 units to the inch cross-section paper.

c. Are arranged consecutively by stations which were reported in the field notes.

d. Are usually plotted from cross section field notes or profile notes that carry offset information on each side of the profile.

e. Horizontal and vertical scales may or may not be the same.

f. The scales used depend on the accuracy required in computing the cross sectional areas, upon the relief, and upon the size of the cross section paper.

g. Cross sections are taken from the center line out in each direction from the center line or taken out from the survey line of the street or borrow pit.

h. Spacing of cross sections is determined by the engineers—the closer together, the more accurate the estimation of volume.

i. Volume of fill between sections can be determined by averaging the end areas in the cross sections and multiplying this average by the distance between sections from beginning section to the last section.

j. Cut and fill areas can be cross hatched or shaded with the cut area shaded differently from the fill area.

Objective 12

Field note reduction for a cross section

Note: Refer to Figure 9 for an example of field notes.

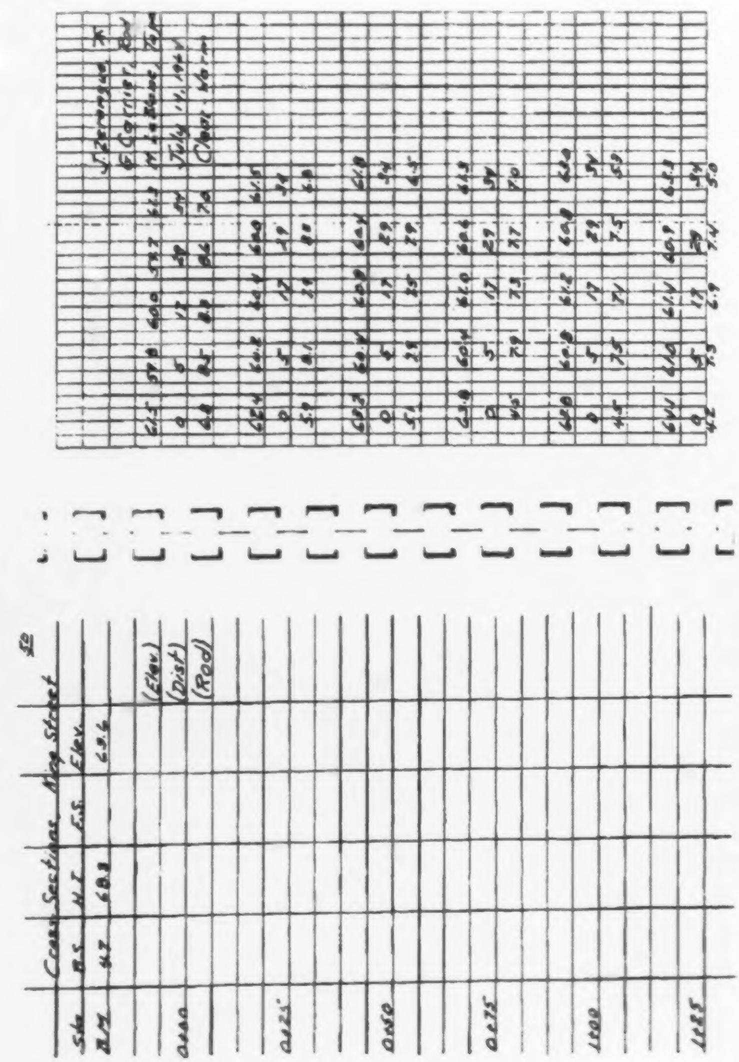
a. Left hand sheet shows notes used in determining the height of the instrument.

b. Right hand sheet shows elevation points on which a reading was taken, the distance out from the control line and the rod reading.

c. The elevation was obtained by subtracting the rod reading from the height of instrument.

d. Only the distance and elevation are used in plotting the cross section.

Figure 9



Cross Sections King Street 50

Sta	B.S.	H.I.	F.S.	Elev.	
BM	4.7	68.3	—	63.6	
					(Elev.)
0+00					(Dist)
					(Rod)
0+25					
0+50					
0+75					
1+00					
1+25					

J. Zeringue, ⊼
E. Carrier, Rod
M. LeBlanc, Tape
July 14, 1984
Clear · Warm

61.5	59.8	60.0	59.7	61.3
0	5	17	29	34
6.8	8.5	8.3	8.6	7.0
62.4	60.2	60.4	60.0	61.5
0	5	17	29	34
5.9	8.1	7.9	8.0	6.8
63.2	60.4	60.8	60.4	61.8
0	5	17	29	34
5.1	7.9	7.5	7.9	6.5
63.8	60.4	61.0	60.6	61.3
0	5	17	29	34
4.5	7.9	7.3	7.7	7.0
64.0	60.8	61.2	60.8	62.4
0	5	17	29	34
4.5	7.5	7.1	7.5	5.9
64.4	61.0	61.4	60.9	63.3
0	5	17	29	34
4.2	7.3	6.9	7.4	5.0

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Objective 13

Plotting cross sections

a. Each section is plotted individually beginning at the top and left-hand side of sheet with station 0+00.

b. Sections are then plotted under each other in order of station numbers.

c. Each point on the cross section is plotted by using a vertical scale for elevation and a horizontal scale for the distance out.

d. Each point is labeled with coordinates. This coordinate number consists of a horizontal line with the distance out written on the bottom and the elevation written on the top.

Example:

60.8 — elevation
5 — distance out from survey line

e. A vertical scale different from that of the horizontal is used to accent the elevation differentials.

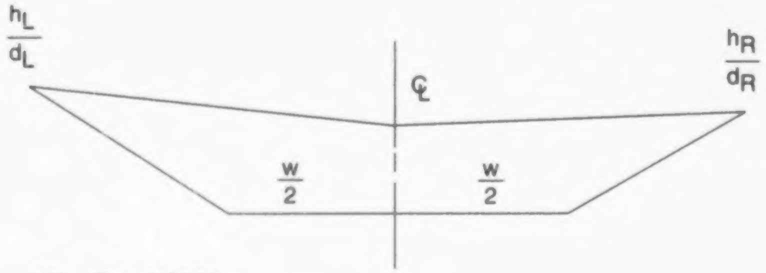
Objective 14

Methods used to determine areas of cross sections—(Student Supplement 8)

Note: Area calculations are easily computed today with special software.

a. Three-level section (pure cut or fill)

Figure 10

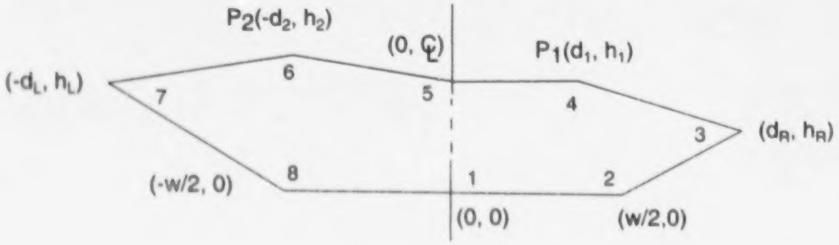


W = Road Width

$\text{Area} = (.5)[w/2\,(h_L + h_R) + \text{℄}\,(d_L + d_R)]$

b. Polygon section (pure cut or fill)

Figure 11


P2(-d2, h2)
(0, ℄)
P1(d1, h1)
(-dL, hL)
7
6
5
4
3
(dR, hR)
(-w/2, 0)
8
1
2
(0, 0)
(w/2,0)

General solution by coordinates:

$$2 \text{ area} = X_n(Y_{n+1} - Y_{Last} + X_{n+1}(Y_{n+2} - Y_n) + X_{n+2}\,(Y_{n+3} - Y_{n+1})$$

$$X_{Last}(Y_n - Y_{Last-1})$$

Area of Given X-section:

$$A = (.5)\,[{}^{w}/2\,(h_R + h_L) + d_1(\text{℄} - h_R) + d_2(\text{℄} - h_L) + d_R h_1 + d_L h_2]$$

Note: The absolute value of the area is shown because all areas are positive.

c. Three-level section (cut and fill mixed)

- Triangle area on **left** side

Figure 12

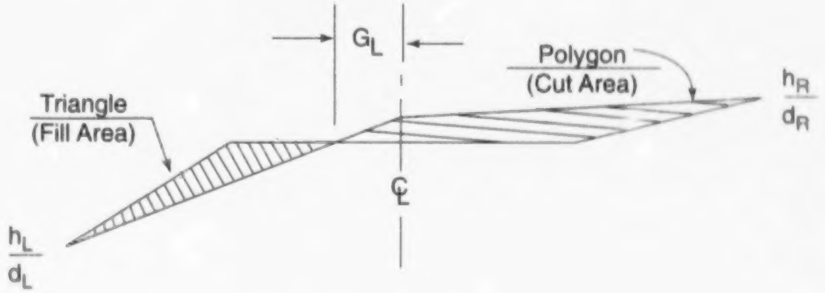
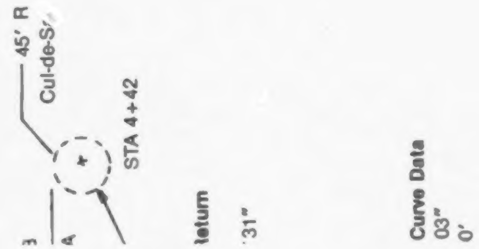

GL
Polygon
(Cut Area)
hR
dR
Triangle
(Fill Area)
℄
hL
dL

Figure 13


45' R
Cul-de-S
STA 4+42
letum
'31"
Curve Data
03"
0'

Grade point (G_L)

$$G_L = \frac{\text{℄}\, d_L}{h_L + \text{℄}}$$

Triangle area

$$A_\Delta = (.5)\ {}^{w}/2h_L - \frac{\text{℄} d_L h_L}{h_L + \text{℄}}$$

Polygon area

$$A_P = (.5)\ {}^{w}/2h_R + \text{℄} d_R + \frac{\text{℄}^2 d_L}{h_L + \text{℄}}$$

- Triangle area on **right** side

Figure 14

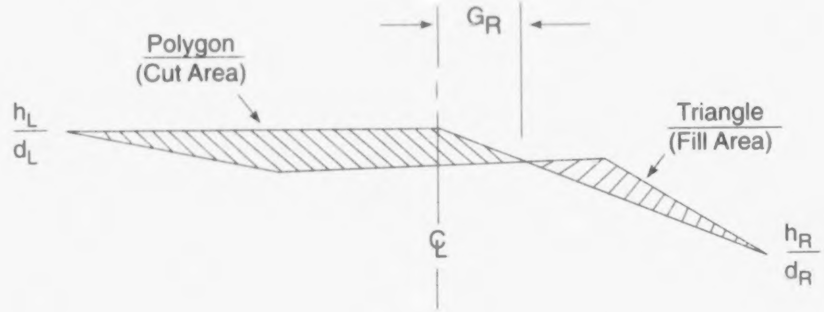
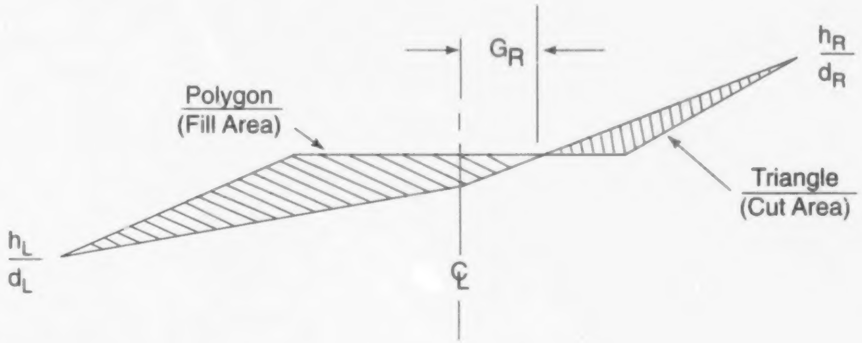

G_R
Polygon
(Cut Area)
h_L
d_L
Triangle
(Fill Area)
℄
h_R
d_R

Figure 15


G_R
$\frac{h_R}{d_R}$
Polygon
(Fill Area)
Triangle
(Cut Area)
$\frac{h_L}{d_L}$
℄

Grade point (G_R)

$$G_R = \frac{\text{℄}\, d_R}{h_R + \text{℄}}$$

Triangle area

$$A_\Delta = (.5)\ {}^{w}/2 h_R - \frac{\text{℄} d_R h_R}{h_R + \text{℄}}$$

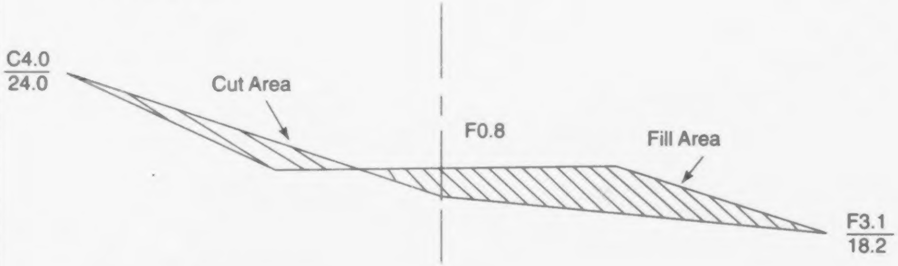
Polygon area

$$A_P = (.5)\ {}^{w}/2 h_L + \text{℄} d_L + \frac{\text{℄}^2 d_R}{h_R + \text{℄}}$$

Same problems for Figure 16

Figure 16

W = 24 ft.


$\frac{C4.0}{24.0}$
Cut Area
F0.8
Fill Area
$\frac{F3.1}{18.2}$

Find: Grade point
Area of cut and fill

Solution: Triangle is on left Use equation shown in C1.

1. Grade point (G_L)

$$G_L = \frac{\text{℄}\, d_L}{h_L + \text{℄}} = \frac{(.8)(24.0)}{40+.8} = \mathbf{4.0\ ft.} \quad \leftarrow \text{Answer}$$

2. Triangle area

$$A_\Delta = (.5)\,\frac{w}{2}\,h_L - \frac{\text{℄}\,d_L h_L}{h_L + \text{℄}}$$

$$= (.5)\,\frac{(24)(4.0)}{2} - \frac{(.8)(24.0)(4.0)}{4.0 + .8} = \mathbf{16\ ft^2\ cut} \longleftarrow \text{Answer}$$

3. Polygon area

$$A_P = (.5)\,\frac{w}{2}h_L + \text{℄}\,d_R + \frac{\text{℄}^2 d_L}{h_L + \text{℄}}$$

$$= (.5)\,\frac{(24)(3.1)}{2} + (.8)(18.2) + \frac{(.8)^2(24.0)}{4.0 + .8}$$

$$= 27.48\ ft^2 = \mathbf{27\ ft^2\ fill} \longleftarrow \text{Answer}$$

Objective 15

Calculating earth volume

a. Volume by average end area

$$V_E = L\left(\frac{A_1 + A_2}{2}\right)$$

Where: V_E = Volume (cu. ft., cu. yd., cu. m.)
L = Distance between areas (ft., m.)
A_1A_2 = End areas (sq. ft., sq. m.)

b. Volume by prismoidal method

$$V_P = {}^{L}\!/_{6}\,(A_1 + 4M + A_2)$$

Where: V_P = Volume (cu. ft., cu. yd., cu. m.)
L = Distance between areas (ft., m.)
A_1A_2 = End areas (sq. ft., sq. m.)
M = Middle section (sq. ft., sq. m.)

c. Prismoidal correction

$$V_C = V_E - V_P$$

For 100 ft. length & 3 level section:

$$V_C = 0.309\,(\text{℄}_1 - \text{℄}_2)\,[d_{L1} + d_{R1}) - (d_{L2} + d_{R2})]$$

= Negative correction in cu. yd.

Example 1:

Note: All cut volumes and fill volumes are calculated separately.

Given: STA	L	℄	R	AREA (sq. ft.)
115	$\frac{C4.0}{16.0}$	C6.0	$\frac{C12.0}{28.0}$	212
116	$\frac{C2.0}{13.0}$	C3.0	$\frac{C8.0}{22.0}$	102
W = 20 ft.				

Solution:

1. Volume by average end area:

$$V_E = L\left(\frac{A_1 + A_2}{2}\right) = 100\left(\frac{212 + 102}{2}\right)$$

$$= 15{,}700 \text{ cu. ft.} = \frac{15{,}700\text{ft}^3}{27 \text{ ft}^3/\text{yd}^3} = \textbf{581 cu. yd.} \leftarrow \text{Answer}$$

2. Volume by prismoidal method:

$$V_P = L/6\,(A_1 + 4M + A_2)$$
$$= 100/6\,(212 + 4M + 102)$$

M = Area calculated from average "L1" "℄," and "R."

$L_{AVG} = C4.0/16.0 + C2.0/13.0/2 = C3.01/14.5$

$\text{℄}_{AVG} = C6.0 + C3.0/2 = C4.5$

$R_{AVG} = C12.0/28.0 + C8.0/22.0/2 = C10.0/25.0$

$M = (.5)[{}^{w}/_{2}(h_L + h_R) + \text{℄}\,(d_L + d_R)]$

$= (.5)[{}^{20}/_{2}(3.0 + 10.0) + 4.5\,(14.5 + 25.0)]$

$= 154 \text{ ft}^2$

$V_P = {}^{100}/_{6}(212 + 4\,(154) + 102) = 15{,}500 \text{ ft}^3$

$$= \frac{15{,}500 \text{ ft}^3}{27 \text{ ft}^3/\text{yd}^3} = \textbf{574 cu. yd.} \leftarrow \text{Answer}$$

3. Prismoidal correction

$V_C = .309\,(\text{℄}_1 - \text{℄}_2)[(d_{L1} + d_{R1}) - (d_{L2} + d_{R2})]$

$= .309\,(6.0 - 3.0)[(16.0 + 28.0) - (13.0 + 22.0)]$

$= 8.3$ cu. yd. $= 8$ cu. yd. (use)

Check: $V_C = V_E - V_P = 581 - 574 = 7$

$V_P = V_P - V_C$

$= 581 - 7 = 574$ cu. yd.

Example 2:

Volume with sidehill sections

Given: STA	L	℄	R	AREA
108+00	$\frac{F2.3}{18.9}$	F3.5	$\frac{F1.3}{15.9}$	F83
108+50	$\frac{C3.1}{18.2}$	C0.8	$\frac{F4.0}{24.0}$	C28,F16
W = 24 ft.				

Find: Volume of cut & fill by average end area.

Solution:

1. Section changes from all fill to cut & fill.
2. Work fill as usual:

$$V_E = L\left(\frac{A_1 + A_2}{2}\right) = 50\left(\frac{83 + 16}{2}\right) = 2475 \text{ ft}^3$$

$$= \frac{2475 \text{ ft}^3}{27 \text{ ft}^3/\text{yd}^3} = \textbf{92 cu. yd. fill} \longleftarrow \text{Answer}$$

3. For lack of more information assume the cut tapers out to zero at STA: 108+00, therefore use $A_1 = 0$ (cut).

$$V_E = L\left(\frac{A_1 + A_2}{2}\right) = 50\left(\frac{0 + 28}{2}\right) = 700 \text{ ft}^3$$

$$= \frac{700 \text{ ft}^3}{27 \text{ ft}^3/\text{yd}^3} = \textbf{26 cu. yd. cut} \longleftarrow \text{Answer}$$

Objective 16

Steps taken for a road construction project

Note: In the past, design and engineering worked independently of the road construction crew. Today they work together as an integral unit.

a. Step 1. Environmental assessment—Public hearings are conducted and studies done to determine any concerns for the projected roadway such as historical issues, wetlands, toxic waste site, etc.

b. Step 2. Scoping—This is where the job is planned out; how to build it, how to manage the project

c. Step 3. Develop a set of working plans; survey the project (topographic or photogrammetric)

d. Step 4. Field inspection review—Discussion of the design in regard to horizontal and vertical curve alignment, pipe locations, etc.

e. Step 5. Final office review—The final critique of the plans before starting the filed work

f. Step 6. Engineering estimates—Bid prices are solicited for work to be done

Example: How many trucks needed to move earth and how many hauls.

g. Step 7. Advertise for bids for construction

h. Step 8. Showing–Show contractors the job

i. Step 9. Contract award—Work to be done to plans, project specials and M&S Standards (materials & structures standards)

Objective 17

Drawings included in a set of highway plans

Note: The order shown here is typical for a highway project, but may vary in your state. Usually the plan set is presented in the order it will be built.

a. Title sheet

b. Standard plans list

c. Typical section and general notes

d. Estimate quantities

e. Structure quantities sheets

f. Tabulation sheets

g. Key map

h. Detail sheets

i. Removal or demolition and utility relocation

j. Pit location sheets

k. Major structure detail sheets

l. Plan and profile sheets (line sheets)

m. Cross section sheets

n. Landscaping and sprinkler plans

o. Roadway striping plans

p. Traffic control signs

q. Storm drainage plan and profile

r. Erosion control plans

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Objective 18

Common scales and drafting standards used in transportation drawings

a. Rural areas—1″ = 100 ft. horizontal scale, 1″ = 10 ft. vertical scale

b. Urban areas—1″ = 50 ft. horizontal scale, 1″ = 5 ft. vertical scale

c. Sheet size

- 22″ x 34″ (Scale: 1″ = 20′)
- Half size plan set (Scale: 1″ = 40′)

Objective 19

Items on a title sheet for a set of highway plans—(Student Supplement 9)

a. Project number

b. State highway number

c. County and state

d. Location map—Shows

- Project limits
- Township and range
- North arrow and bar graph
- Beginning and ending station
- Major equations
- Limits of previous projects
- Major structure numbers (both existing and proposed)
- Detour routes and no work sections
- Railroad crossings, canals, streams, and rivers

e. Length and design data

f. Index of sheets

g. Approval blocks

Objective 20

Detail sheets—(Student Supplement 10)

a. Show information necessary for constructing a special item.

b. Unrelated details may be shown on the same sheet as long as they are distinctly separated.

c. Details should be arranged in logical order.

d. Interchange details may have to be put on more than one sheet. Match lines are clearly marked on each sheet.

Information Sheet

Objective 21

Drafting plan views, profiles, and cross sections—(Student Supplement 11)

a. Drafting of plan views

- Show survey alignment as dashed
- Show projected alignment as solid

  Note: Line fonts will vary from agency to agency.
- Show curve points, stations and tick marks, bearings, and match lines.
- Show tick marks on top of the alignment; every fifth mark going through the alignment and station is written near it.
- Show bearings on top of tangent lines.
- Do not repeat information from one sheet to the next.
- Begin and end the sheet on stations divisible by five.
- Draw physical features in exact position and position labels, dimensions, notes, and other data for clarity.
- Right-of-way area may require data for construction. Place other notes and data outside the right-of-way.
- A suggested order for preparation of a plan sheet is
  - Index block
  - Basic control lines: center lines, radial lines, station tick marks, etc.
  - Existing topography and walks, curbs, gutters, streams, buildings, shrubs, etc. Use light linework.
  - Planned construction feature—roadways, drainage, substructures, etc. Use heavier linework.
  - Lettering, labels, data, and notes—Curve data, equations, tangent bearings, land lines, general topography, street and road names, construction line designation, north arrow, construction notes, sheet references, and title.
- Select appropriate line types for
  - Survey lines
  - Curve lines
  - Tangent portion
  - Tick marks
  - Topography
- Show right-of-way (R/W) lines as long dash line, then two short lines.

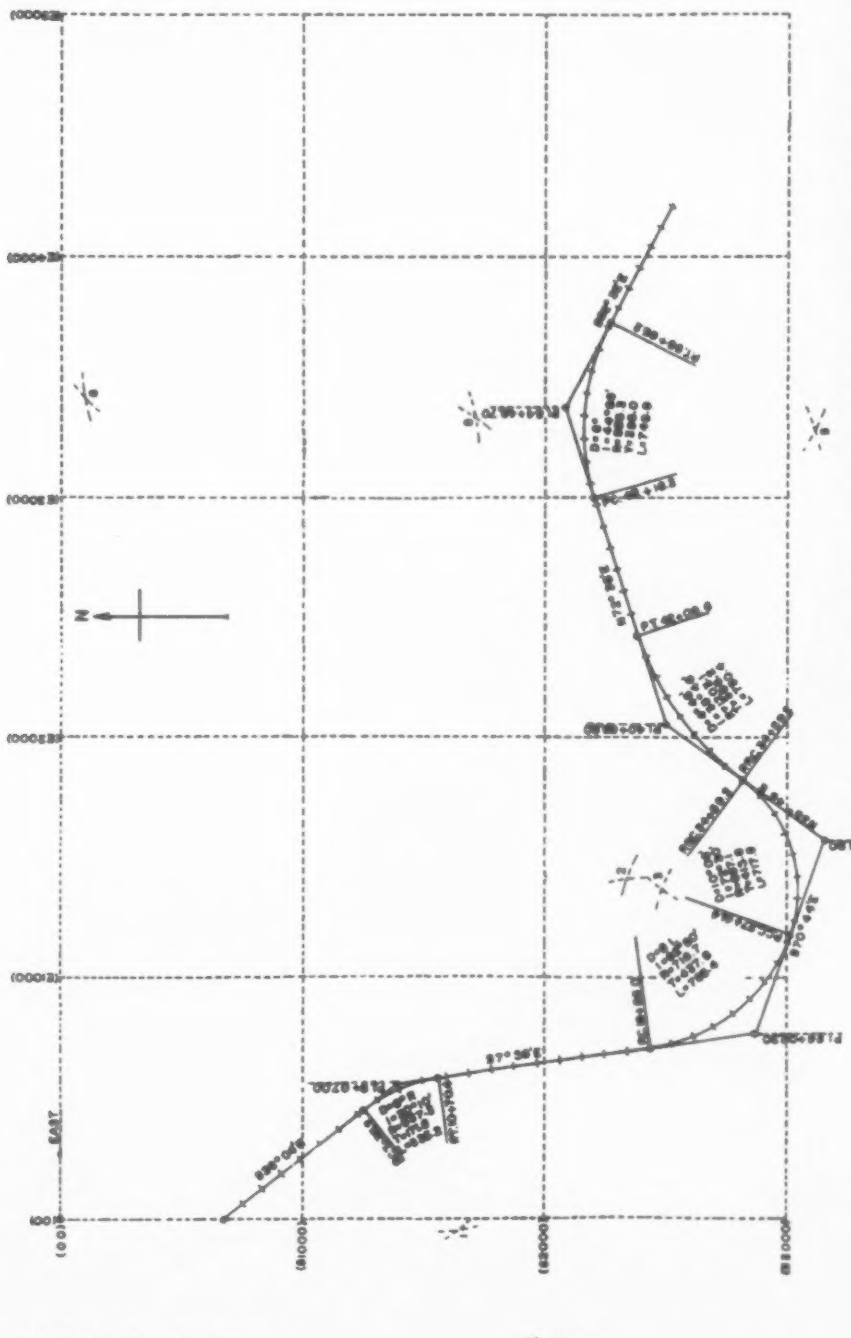
b. Drafting of profiles

- Show grades for the alignment to be constructed.
- Correspond stations from the plan view.
- Plot ground line under roadway profile grade as a dashed line or light thin line.
- Show elevations to the hundredth of a foot.
- Show grades to the ten thousandth of a percent (grade percentage in ft./sta. or ft./100 ft.).
- Arrange profile sheet with two inches left on bottom of sheet for the earthwork breakout.
- Show the beginning and ending stations which tie to adjacent project.
- Give bench mark data just below the margin of the profile strip or just above in the plan portion.

c. Drafting of cross sections

- Note centerline of survey on the sheet.
- Plot elevations and distances left and right of centerline.
- Draw ground line.
- Use roadway template for drawing profile grade and typical section applicable for each particular cross section station.
- Draw in pencil to facilitate changes.
- Note station number and ground elevation at centerline under each cross section.
- Note scale and type of cross section at the upper right corner of the sheet.
- Write area of each section within the section and state if it is cut or fill.
- Write volume of earth between the sections and state if it is cut or fill.
- Connect first and last points of each section by a dashed line.

Student Supplement 1—Plotting a Traverse with Angles and Coordinates



From *Map Drafting and Related Computations for Plane Surveying: Field Book*. Reprinted with permission of the Vocational Curriculum Development and Research Center, Natchitoches, Louisiana.

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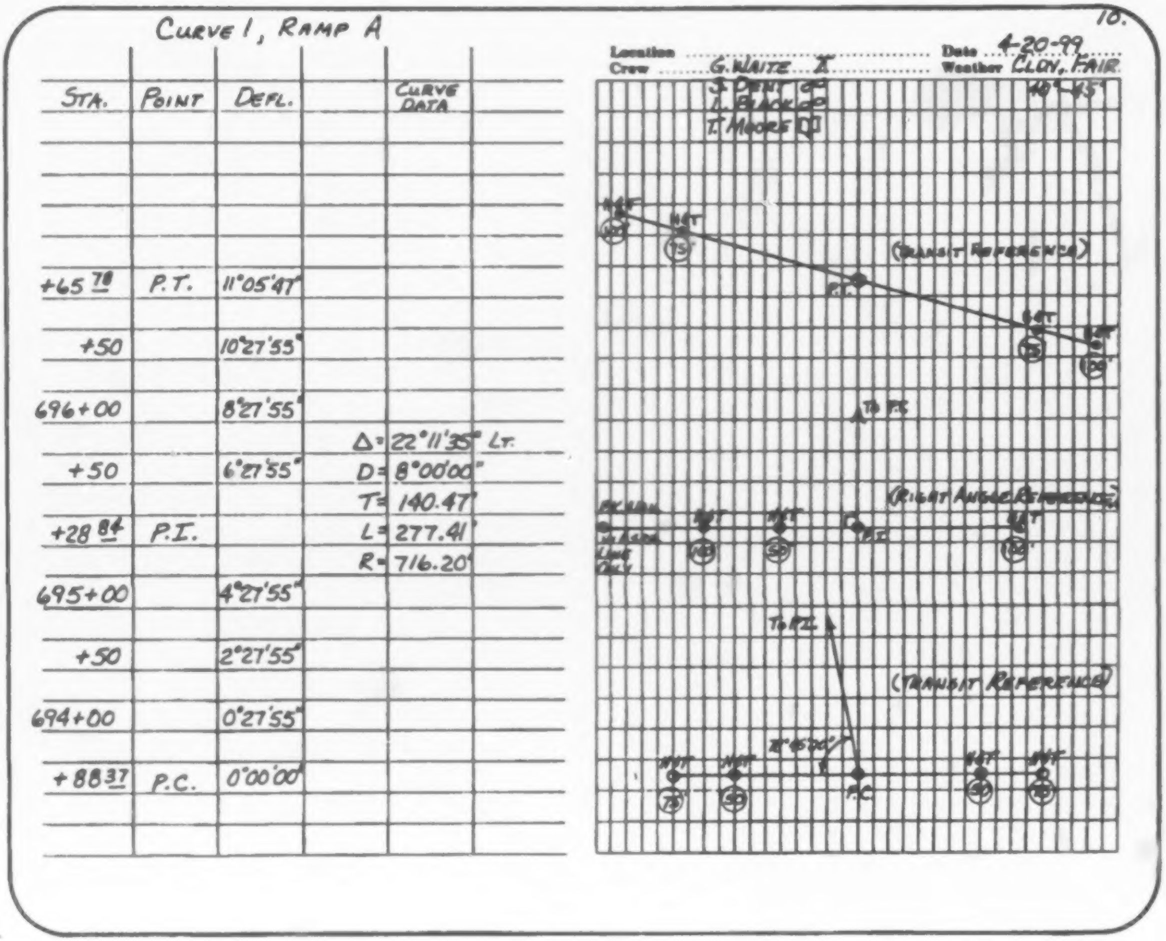
Student Supplement 2—Field Notes for a Simple Curve



CURVE 1, RAMP A

STA.	POINT	DEFL.		CURVE DATA	
+65 $^{\underline{78}}$	P.T.	11°05'47"			
+50		10°27'55"			
696+00		8°27'55"			
				Δ=22°11'35" LT.	
+50		6°27'55"		D=8°00'00"	
				T=140.47'	
+28 $^{\underline{84}}$	P.I.			L=277.41'	
				R=716.20'	
695+00		4°27'55"			
+50		2°27'55"			
694+00		0°27'55"			
+88 $^{\underline{37}}$	P.C.	0°00'00"			

10.

Location ....

Crew G. WAITE X
S. DENT
L. BLACK
T. MOORE

Date 4-20-99

Weather CLDY, FAIR 40°-45°

(TRANSIT REFERENCE)
75'
P.T.
TO P.I.
(RIGHT ANGLE REFERENCE)
P.I.
(TRANSIT REFERENCE)
TO P.I.
P.C.
75'
50'

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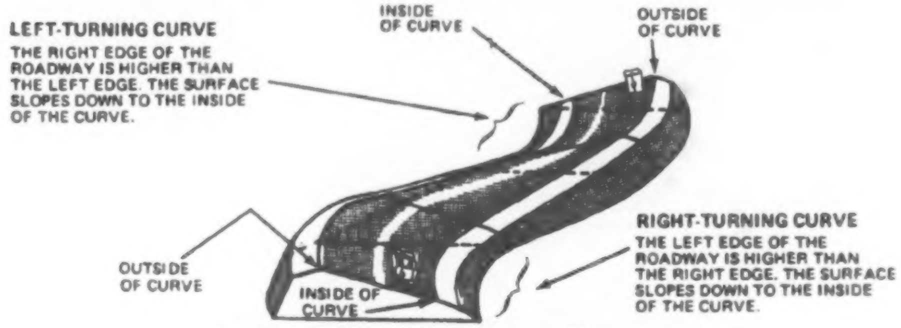
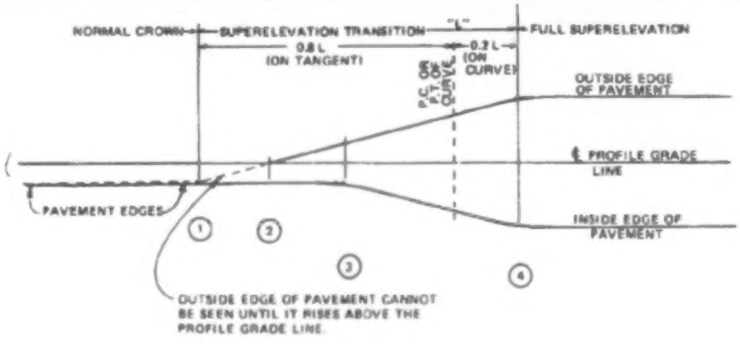
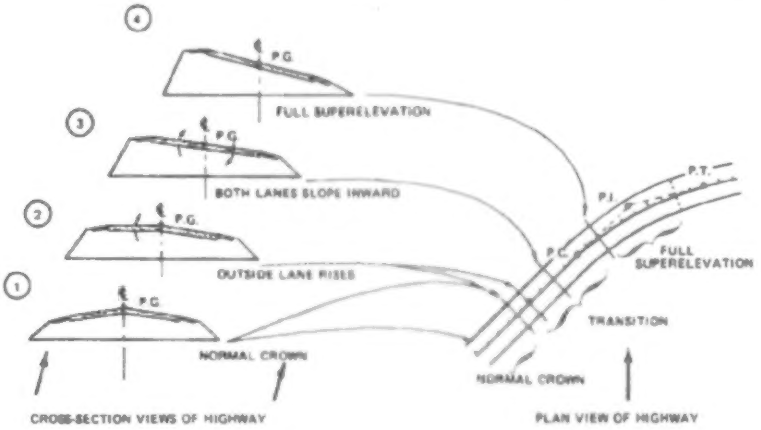
Student Supplement 3—Superelevations of a Roadway


LEFT-TURNING CURVE
THE RIGHT EDGE OF THE ROADWAY IS HIGHER THAN THE LEFT EDGE. THE SURFACE SLOPES DOWN TO THE INSIDE OF THE CURVE.
INSIDE OF CURVE
OUTSIDE OF CURVE
RIGHT-TURNING CURVE
THE LEFT EDGE OF THE ROADWAY IS HIGHER THAN THE RIGHT EDGE. THE SURFACE SLOPES DOWN TO THE INSIDE OF THE CURVE.
OUTSIDE OF CURVE
INSIDE OF CURVE

Left- and Right-Turning Curves


NORMAL CROWN
SUPERELEVATION TRANSITION
"L"
FULL SUPERELEVATION
0.8 L (ON TANGENT)
0.2 L (ON CURVE)
P.C. OR P.T. OF CURVE
OUTSIDE EDGE OF PAVEMENT
℄ PROFILE GRADE LINE
INSIDE EDGE OF PAVEMENT
PAVEMENT EDGES
①
②
③
④
OUTSIDE EDGE OF PAVEMENT CANNOT BE SEEN UNTIL IT RISES ABOVE THE PROFILE GRADE LINE

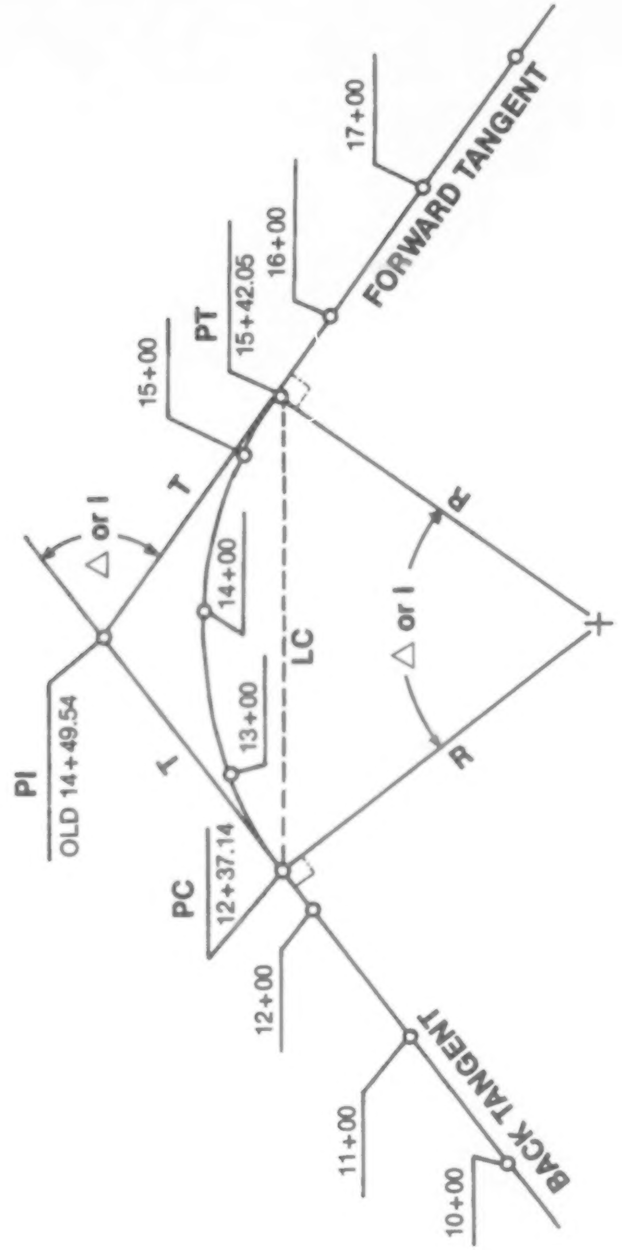
Profile View of a Superelevation Transition


④
℄ P.G.
FULL SUPERELEVATION
③
℄ P.G.
BOTH LANES SLOPE INWARD
②
℄ P.G.
OUTSIDE LANE RISES
①
℄ P.G.
NORMAL CROWN
CROSS-SECTION VIEWS OF HIGHWAY
P.T.
P.I.
P.C.
FULL SUPERELEVATION
TRANSITION
NORMAL CROWN
PLAN VIEW OF HIGHWAY

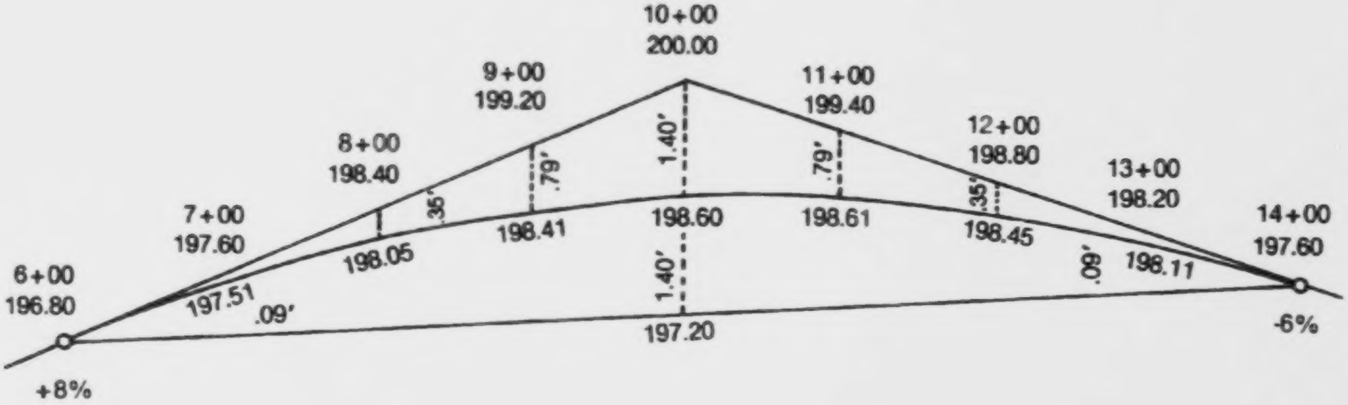
Cross-Section and Plan Views of a Highway in Superelevation

From *Civil Engineering Drafting* by Roy H. and James R. Wirshing. ©1983. Reproduced with permission of Glencoe/McGraw-Hill.

Student Supplement 4—Horizontal Curve

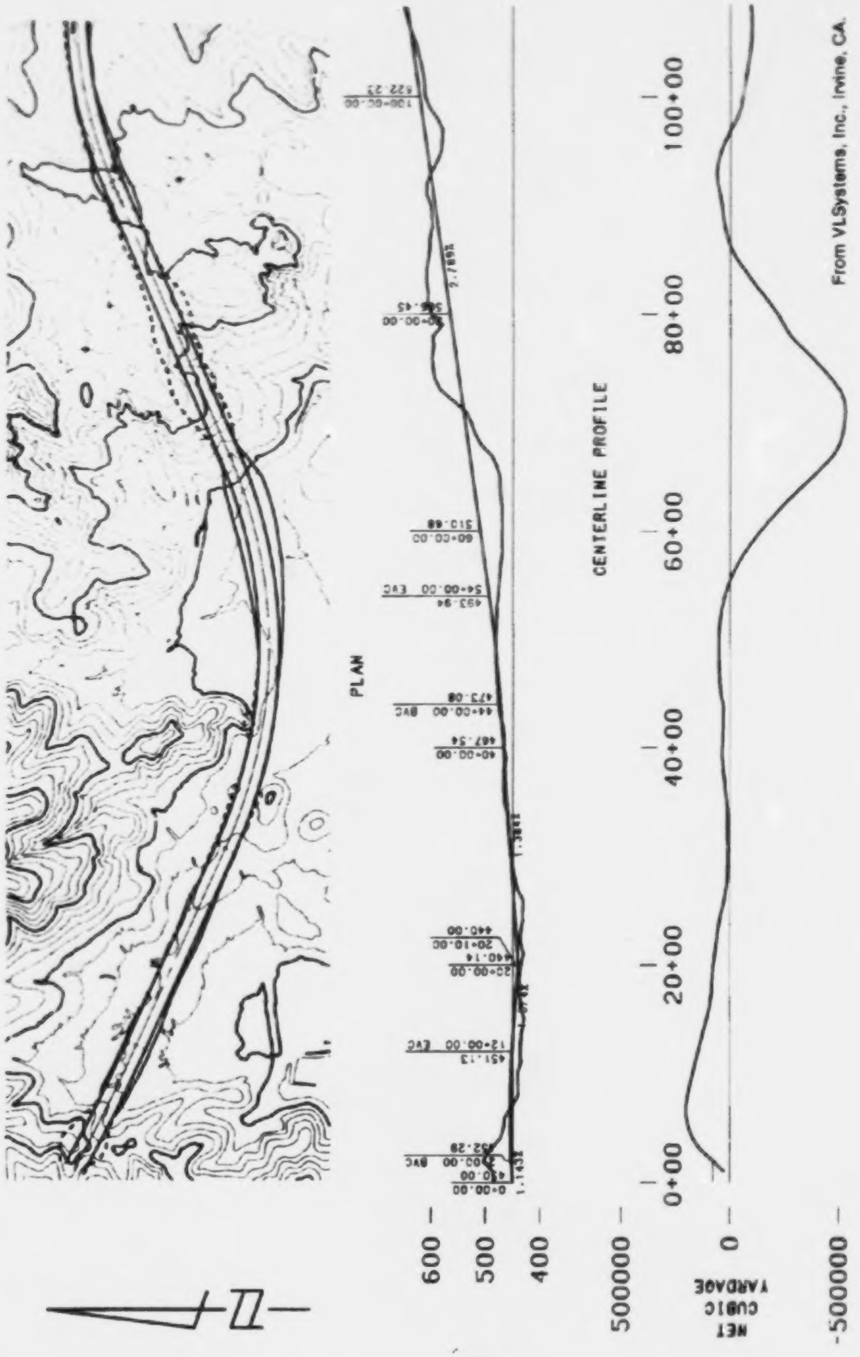

17+00
16+00
FORWARD TANGENT
PT
15+42.05
15+00
T
Δ or I
R
14+00
LC
Δ or I
PI
OLD 14+49.54
13+00
T
R
PC
12+37.14
12+00
11+00
10+00
BACK TANGENT

Student Supplement 5—Vertical Curve


10+00
200.00
9+00
199.20
11+00
199.40
8+00
198.40
12+00
198.80
13+00
198.20
7+00
197.60
14+00
197.60
6+00
196.80
1.40'
.79'
.79'
.35'
.35'
.09'
.09'
198.60
198.41
198.61
198.05
198.45
198.11
197.51
1.40'
197.20
+8%
-6%

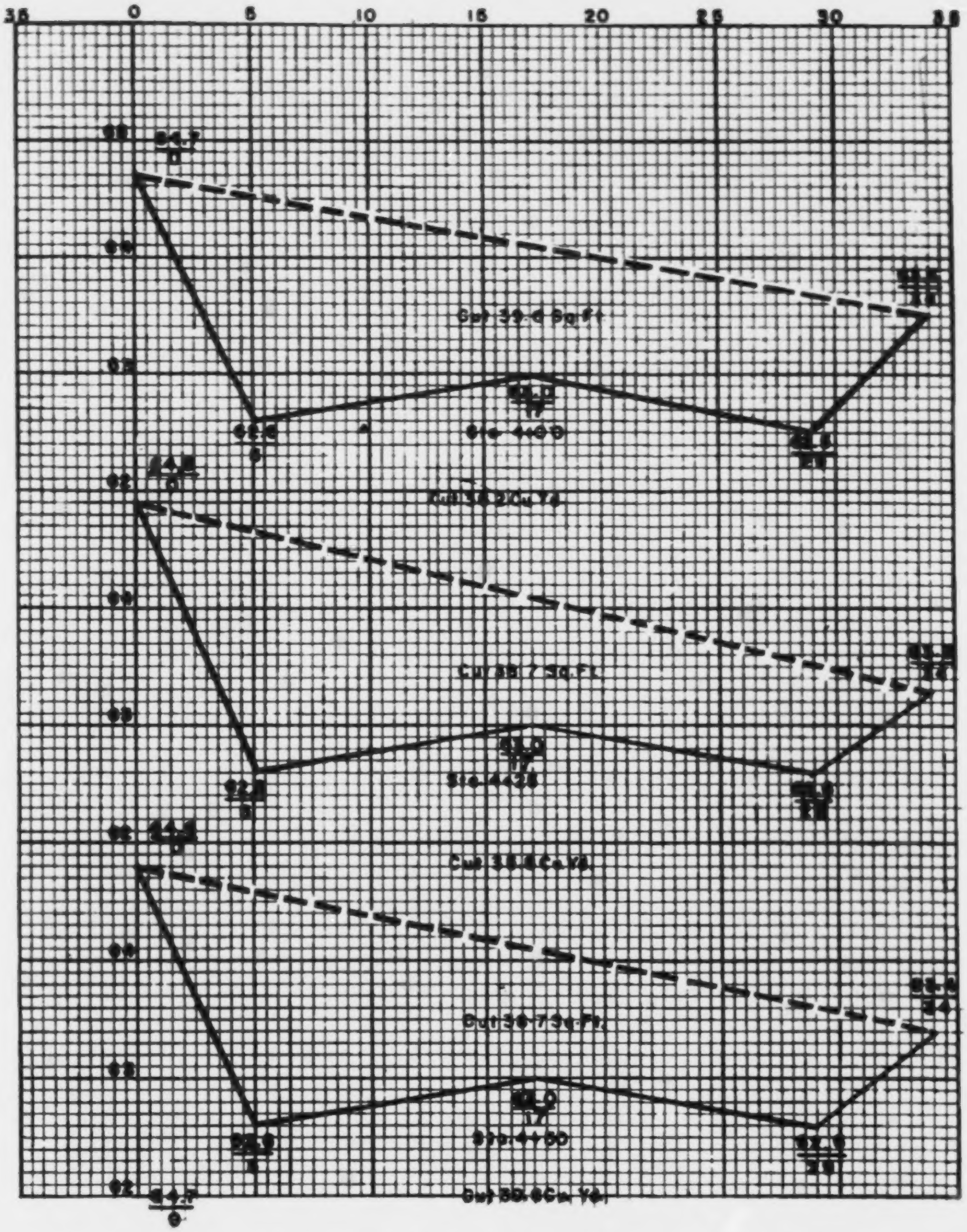
STATION	6=A	7	8	9	10	11	12	13	14=C
Elevation of Tangent	196.80	197.60	198.40	199.20	200.00	199.40	198.80	198.20	197.60
Tangent Offset	0.00	.09	.35	.79	1.40	.79	.35	.09	0.00
Elevation of Curve	196.80	197.51	198.05	198.41	198.60	198.61	198.45	198.11	197.60

Student Supplement 6—Example of a Plan and Profile


PLAN
CENTERLINE PROFILE
0+00
20+00
40+00
60+00
80+00
100+00
600
500
400
500000
0
-500000
NET
CUBIC
YARDAGE

From VLSystems, Inc., Irvine, CA.

Student Supplement 7—Example of Cross Sections


0
5
10
15
20
25
30
35
Sta. 4+00
Sta. 4+25
Sta. 4+50

From *Map Drafting and Related Computations for Plane Surveying: Field Book.* Reprinted with permission of the Vocational Curriculum Development and Research Center, Natchitoches, Louisiana.

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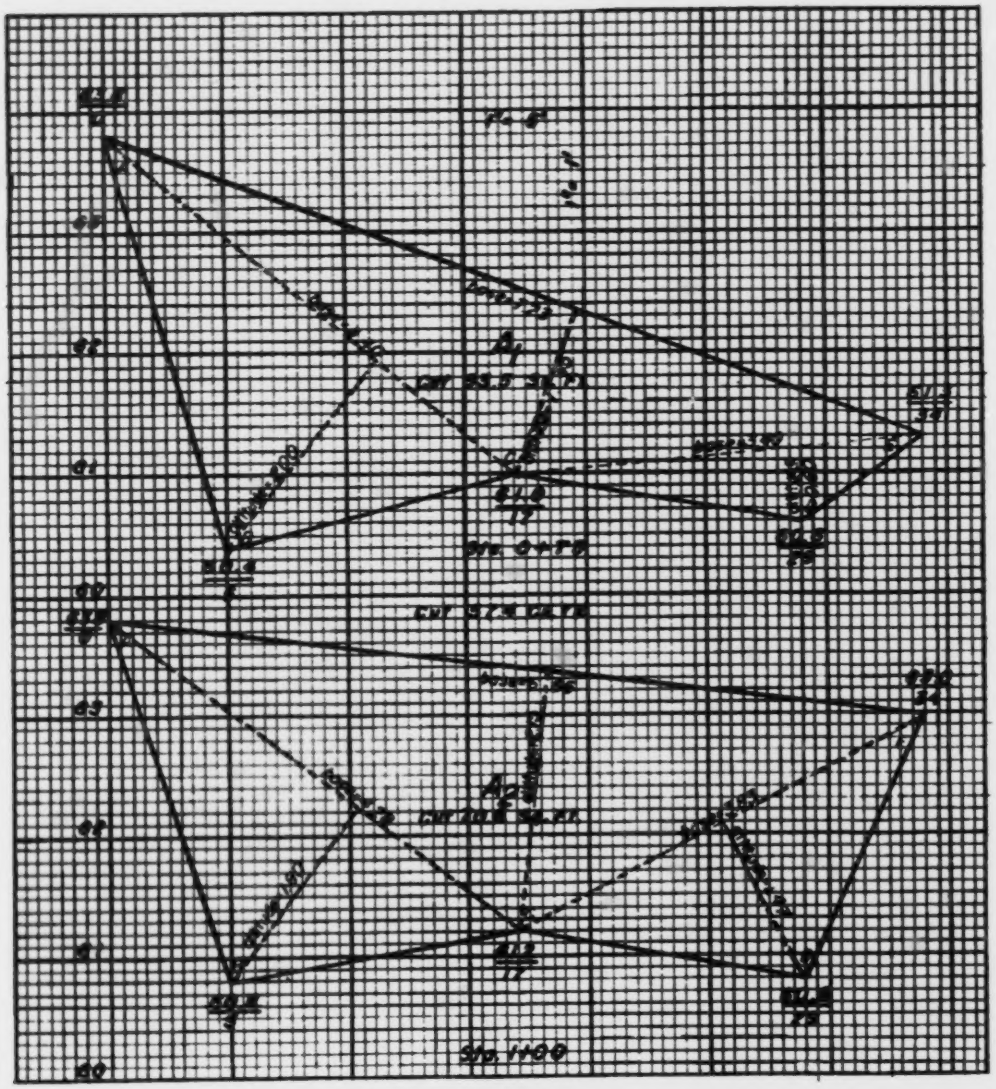
Student Supplement 8—Areas of Cross Sections



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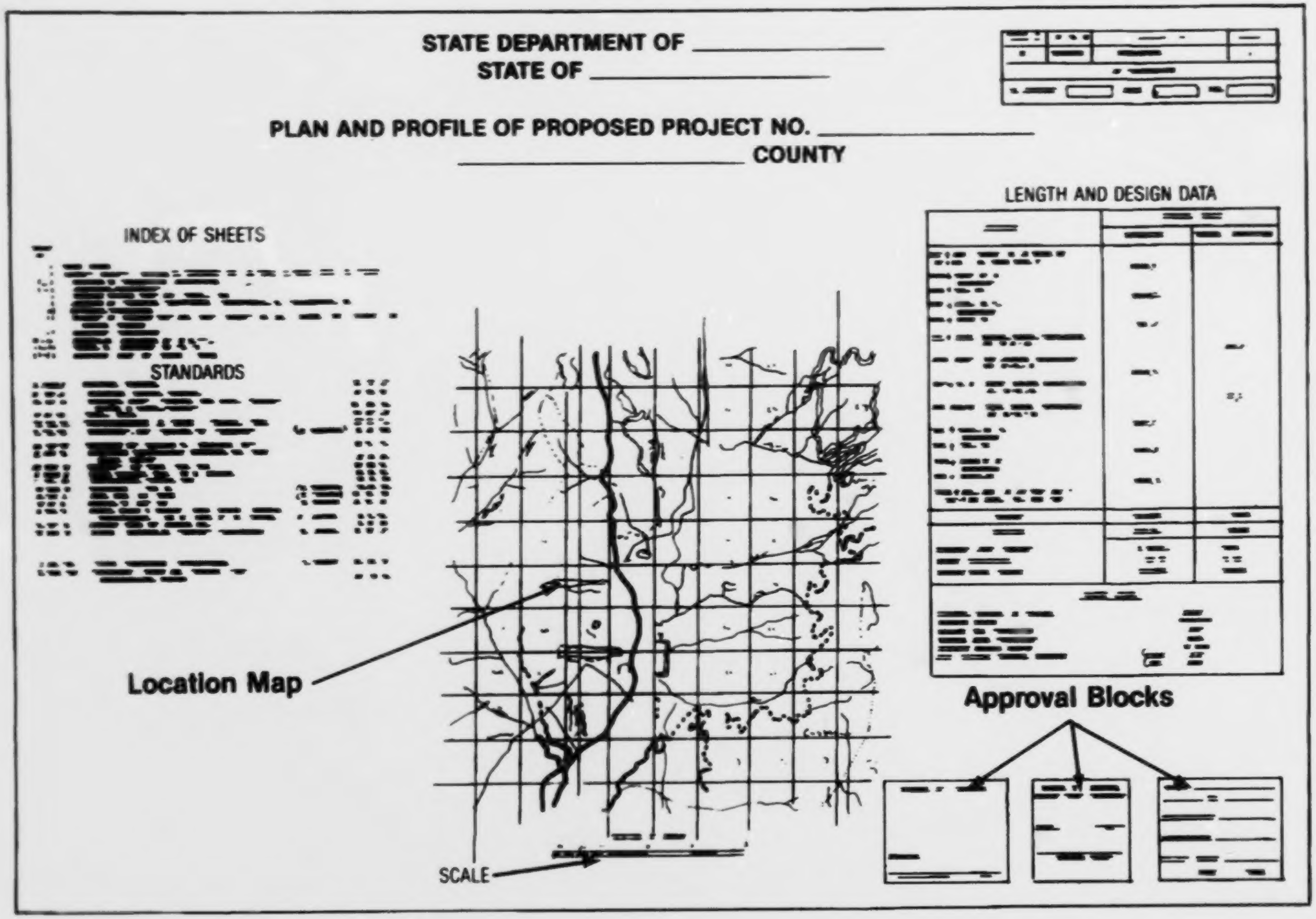
Student Supplement 9—Typical Title Sheet



STATE DEPARTMENT OF ______________

STATE OF ______________

PLAN AND PROFILE OF PROPOSED PROJECT NO. ______________

______________ COUNTY

INDEX OF SHEETS
STANDARDS
LENGTH AND DESIGN DATA
Location Map
Approval Blocks
SCALE

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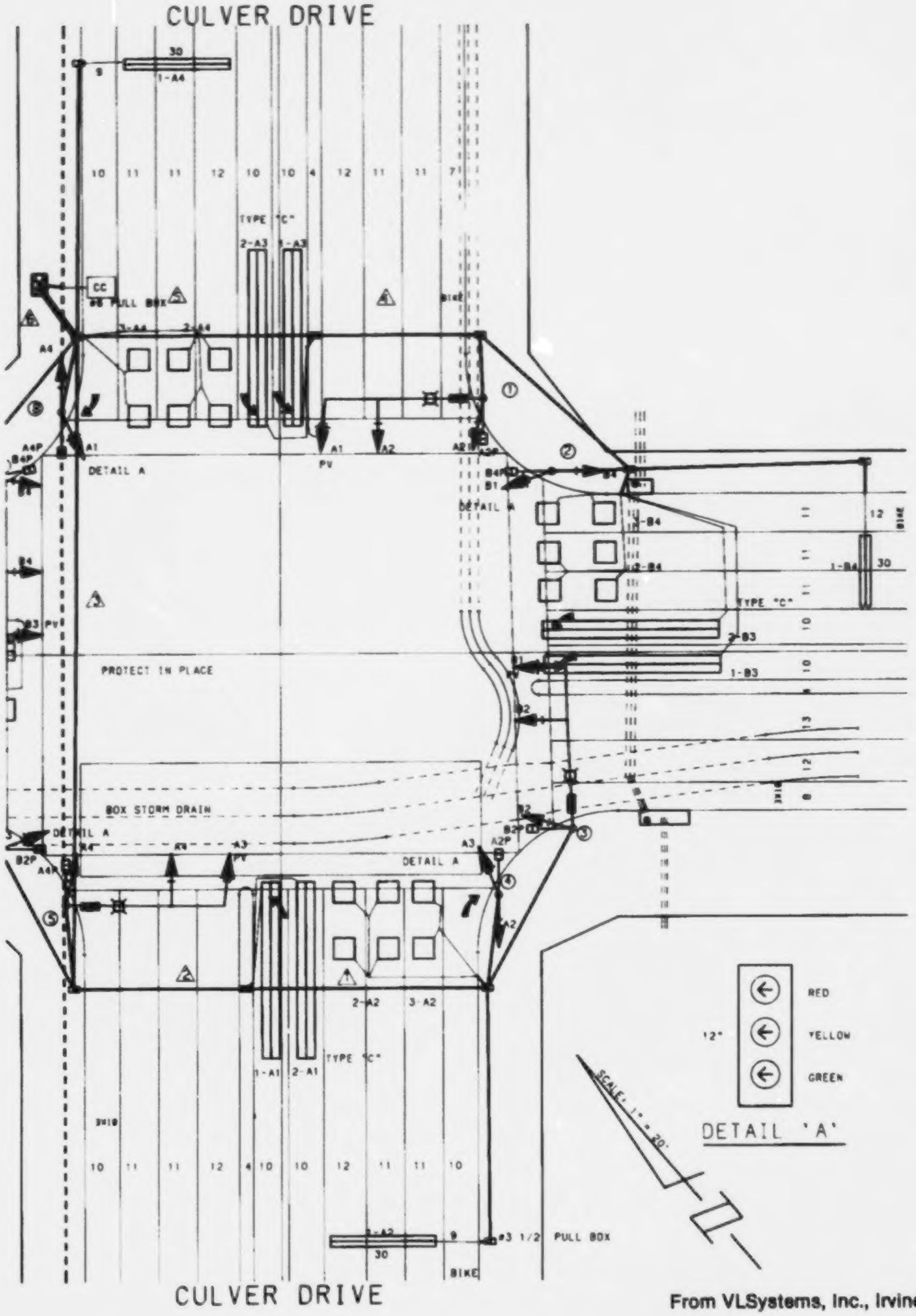
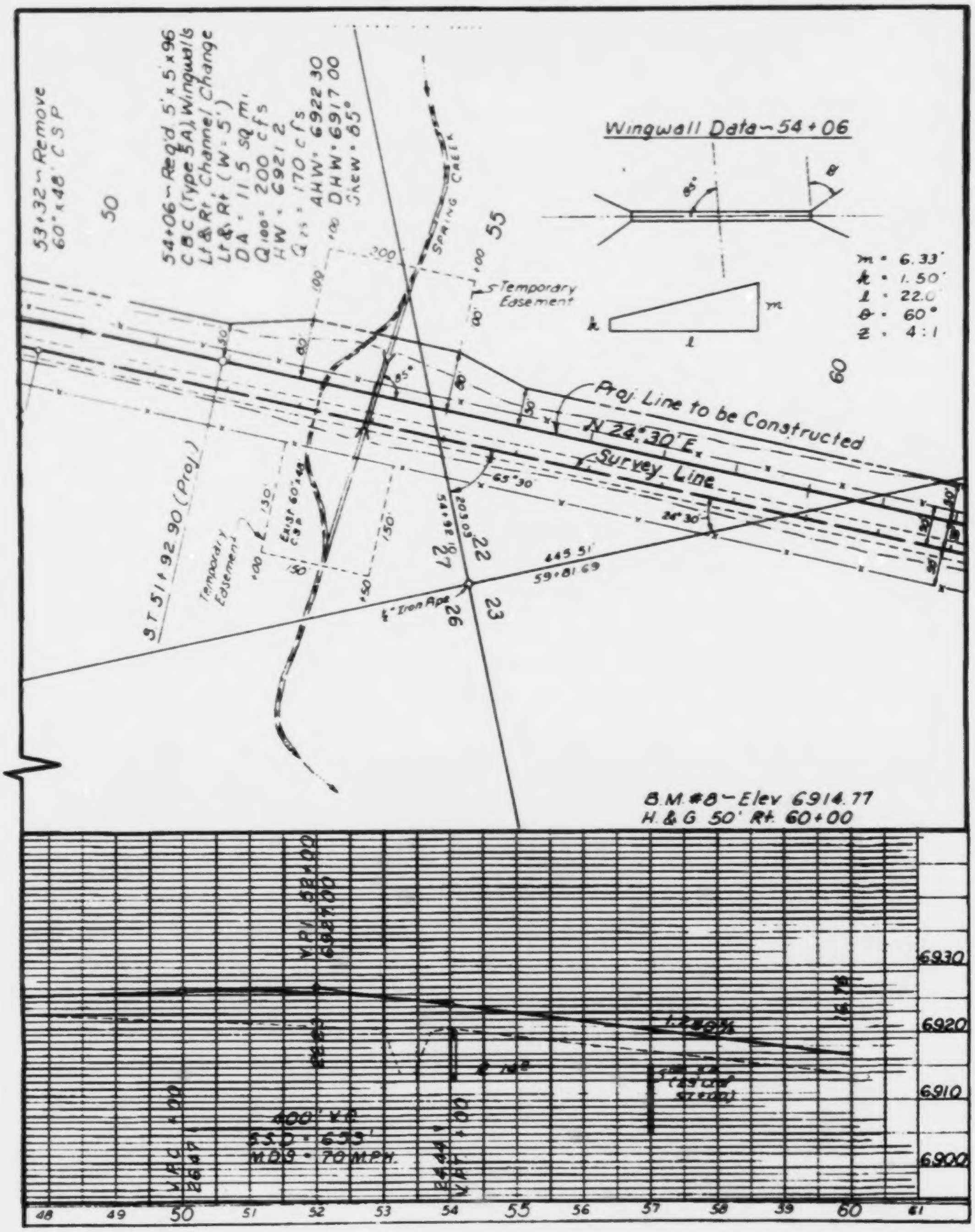
Student Supplement 10—Example of a Highway Detail (Traffic Signal Plan)


CULVER DRIVE
MAIN STREET
CULVER DRIVE
TYPE "C"
CC
PULL BOX
DETAIL A
PROTECT IN PLACE
BOX STORM DRAIN
BIKE
3 1/2 PULL BOX
RED
YELLOW
GREEN
12"
DETAIL 'A'
SCALE: 1" = 20'

From VLSystems, Inc., Irvine, CA.

Student Supplement 11—Typical Plan and Profile


53+32 ~ Remove
60"x48" CSP
50
54+06 ~ Req'd 5'x5'x96 CBC (Type 5A), Wingwalls Lt & Rt, Channel Change Lt & Rt (W = 5')
DA = 11.5 sq mi
Q100 = 200 cfs
HW = 6921.2
Q75 = 170 cfs
AHW = 6922.30
DHW = 6917.00
Skew = 85°
Spring Creek
55
Wingwall Data ~ 54+06
m = 6.33'
k = 1.50'
l = 22.0'
θ = 60°
z = 4:1
60
Temporary Easement
Proj. Line to be Constructed
N 24°30' E
Survey Line
65°30'
24°30'
Exist 60"x48" CSP
ST 51+92.90 (Proj.)
Temporary Easement
645.51'
59+81.69
½" Iron Pipe
27 22
26 23
B.M. #8 ~ Elev 6914.77
H. & G. 50' Rt. 60+00
VPI 52+00
6927.00
400' VC
SSD = 635'
MDS = 70 MPH
VPC 50+00
VPT 54+00
6930
6920
6910
6900
48
49
50
51
52
53
54
55
56
57
58
59
60
61

Courtesy of Colorado Department of Highways.

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Objective 22

Assignment Sheet 1—Lay Out Open Traverses Using Several Methods

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	**Rating**
• Accuracy of measurement	______
• Traverse closure ± .065″	______
• Assignment neat and legible	______

Basic Skills

Reading Mathematics Technology

Part I

Open Bearing Traverses

1. Start all traverses from the center of a 17 x 22 in. sheet of paper.
2. Plot each traverse to the scale indicated below.
3. Identify each point with a small circle and letter; label each traverse leg with bearing and distance.
4. Label each traverse by number and scale used in a place where it most clearly identifies with the traverse.
5. In the lower left hand corner provide a table with the following headings: Traverse, Closing, Distance, Closing Bearing.

   Note: Closure is from the last to the first point.
6. Provide a border, title block, and north arrow.

Traverse #1: Scale 1″ = 200′

Course	Length	Bearing
A-B	364.13	N 32°0′ E
B-C	239.20	N 83°30′ E
C-D	382.5	N 51°0′ W
D-E	241.6	Due North
E-F	310.7	N 16°30′ W
F-G	379.1	S 64°0′ E
G-H	380.0	N 71°30′ E
H-A	________	________

Traverse #2: Scale 1″ = 30′

Course	Length	Bearing
A-B	74.0	N 86°30′ E
B-C	39.2	N 13°30′ E
C-D	54.1	N 67°0′ E
D-E	55.8	N 25°30′ E
E-F	40.2	S 36°30′ E
F-G	52.0	N 43°0′ E
G-H	41.9	S 64°0′ E
H-A	________	________

Assignment Sheet 1

Traverse #3: Scale 1″ = 50′

Course	Length	Bearing
A-B	81.5	S 27°30′ E
B-C	64.5	S 9°0′ E
C-D	113.6	S 21°30′ E
D-E	134.0	N 14°0′ E
E-F	65.1	S 88°30′ E
F-G	86.8	N 24°30′ E
G-H	174.5	S 70°30′ E
H-A	________	________

Traverse #4: Scale 1″ = 60′

Course	Length	Bearing
A-B	129.6	S 27°0′ W
B-C	120.0	S 16°0′ E
C-D	65.3	S 44°30′ E
D-E	130.5	S 18°0′ W
E-F	153.2	N 19°30′ W
F-G	51.7	N 22°30′ W
G-H	78.5	N 89°0′ W
H-A	________	________

Part II

Open Azimuth North Traverses

1. Start all traverses from the center of a 17 x 22 in. sheet of paper.
2. Plot each traverse to the scale indicated below.
3. Identify each point with a small circle and letter; label each traverse leg with bearing and distance.
4. Label each traverse by number and scale used in a place where it most clearly identifies with the traverse.
5. In the lower left hand corner provide a table with the following headings: Traverse, Closing, Distance, Closing Bearing.

   Note: Closure is from the last to the first point.
6. Provide a border, title block, and north arrow.

Traverse #1: Scale 1″ = 60′

Course	Length	Azimuth (N)
A-B	108.0	077°0′
B-C	47.5	332°30′
C-D	144.8	108°30′
D-E	176.2	340°30′
E-F	152.0	102°30′
F-G	109.3	339°30′
G-H	99.0	302°30′
H-I	89.2	232°30′
I-J	102.0	0°0′
J-A	________	________

Traverse #2: Scale 1″ = 500′

Course	Length	Azimuth (N)
A-B	465	188°0′
B-C	895	114°30′
C-D	580	148°0′
D-E	565	247°30′
E-F	1200	120°0′
F-G	900	56°30′
G-H	676	358°30′
H-I	808	285°0′
I-J	682	161°30′
J-A	________	________

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Traverse #3: Scale 1″ = 30′

Course	Length	Azimuth (N)
A-B	46.6	240°0′
B-C	44.7	267°30′
C-D	42.5	212°0′
D-E	74.8	224°0′
E-F	49.5	279°30′
F-G	37.0	26°0′
G-H	45.7	42°30′
H-I	59.8	279°0′
I-J	21.5	201°0′
J-A		

Traverse #4: Scale 1″ = 2,000′

Course	Length	Azimuth (N)
A-B	2500	288°30′
B-C	3175	32°30′
C-D	2825	18°0′
D-E	2600	302°0′
E-F	5775	234°30′
F-G	4290	351°30′
G-H	2064	226°30′
H-I	4900	276°30′
I-J	4400	57°0′
J-A		

Part III

Open Deflection Angle Traverses

1. Start all traverses from the center of a 17 x 22 in. sheet of paper.
2. Plot each traverse to the scale indicated below.
3. Identify each point with a small circle and letter; label each traverse leg with bearing and distance.
4. Label each traverse by number and scale used in a place where it most clearly identifies with the traverse.
5. In the lower left hand corner provide a table with the following headings: Traverse, Closing, Distance, Closing Bearing.

   Note: Closure is from the last to the first point.
6. Provide a border, title block, and north arrow.

Traverse #1: Scale 1″ = 300′

Course	Length	Defl. Angle
A-B	461	N 61°0′ E
B-C	699	54°30′ L
C-D	428	99°30′ R
D-E	386	41°0′ L
E-F	640	105°0′ L
F-G	451	62°0′ L
G-H	524	43°30′ L
H-A		

Traverse #2: Scale 1″ = 40′

Course	Length	Defl. Angle
A-B	70.5	S 11°0′ E
B-C	34.8	45°30′ L
C-D	84.2	37°30′ L
D-E	39.3	51°0′ L
E-F	51.5	71°0′ L
F-G	59.0	72°0′ L
G-H	39.0	53°30′ R
H-A		

Assignment Sheet 1

Traverse #3: Scale 1″ = 50′

Course	Length	Defl. Angle
A-B	58.0	S 43°0′ W
B-C	81.5	23°0′ R
C-D	104.5	39°30′ L
D-E	85.0	26°30′ R
E-F	39.0	18°30′ R
F-G	86.0	42°30′ R
G-H	166.5	120°0′ R
H-I	73.0	113°0′ L
I-J	81.7	51°0′ L
J-A	________	________

Traverse #4: Scale 1″ = 200′

Course	Length	Defl. Angle
A-B	304	N 20°0′ W
B-C	401	115°30′ L
C-D	163	115°30′ R
D-E	301	24°30′ L
E-F	442	90°30′ L
F-G	758	101°30′ R
G-H	387	101°0′ R
H-I	339	52°0′ R
I-J	741	74°30′ L
J-A	________	________

Part IV

Open Angle Right Traverses

1. Start all traverses from the center of a 17 x 22 in. sheet of paper.
2. Plot each traverse to the scale indicated below.
3. Identify each point with a small circle and letter; label each traverse leg with bearing and distance.
4. Label each traverse by number and scale used in a place where it most clearly identifies with the traverse.
5. In the lower left hand corner provide a table with the following headings: Traverse, Closing, Distance, Closing Bearing.

   Note: Closure is from the last to the first point.

6. Provide a border, title block, and north arrow.

Traverse #1: Scale 1″ = 200′

Course	Length	Angle RT
A-B	245	N 30°0′ W
B-C	474	138°30′
C-D	332	304°0′
D-E	251	102°30′
E-F	392	256°30′
F-G	320	291°0′
G-H	534	76°0′
H-I	229	325°30′
I-J	304	72°0′
J-A	________	________

Traverse #2: Scale 1″ = 60′

Course	Length	Angle RT
A-B	97.5	S 48°0′ E
B-C	95.6	234°30′
C-D	94.0	191°30′
D-E	85.2	36°0′
E-F	131.4	166°0′
F-G	50.1	129°30′
G-H	95.9	151°30′
H-I	133.4	258°30′
I-J	90.2	55°30′
J-A	________	________

Traverse #3: Scale 1″ = 30′

Course	Length	Angle RT
A-B	50.3	S 29°0′ W
B-C	25.0	228°30′
C-D	49.2	119°0′
D-E	72.9	211°30′
E-F	63.4	318°0′
F-G	39.7	76°30′
G-H	50.8	154°0′
H-I	64.2	221°30′
I-J	63.9	323°0′
J-A	________	________

Traverse #4: Scale 1″ = 50′

Course	Length	Angle RT
A-B	87.1	S 86°0′ W
B-C	48.4	153°30′
C-D	88.1	263°30′
D-E	117.8	125°30′
E-F	130.2	238°30′
F-G	80.3	41°30′
G-H	86.4	196°0′
H-I	43.7	82°30′
I-J	34.3	88°30′
J-A	________	________

Part V

Open Traverses by Coordinates

1. Start all traverses from the center of a 17 x 22 in. sheet of paper.
2. Plot each traverse to the scale indicated below.
3. Label each point with letters and (x, y) coordinates.
4. Label each traverse by number and scale used in a place where it most clearly identifies with the traverse.
5. In the right margin, provide a table for each traverse with the headings: Course, Length, Bearing.

Traverse #1: Scale 1″ = 300′

Point	X-Coord.	Y-Coord.
A	0	0
B	403	224
C	482	918
D	894	800
E	1244	963
F	832	1453
G	391	1360
H	94	928

Traverse #2: Scale 1″ = 40′

Point	X-Coord.	Y-Coord.
A	0.0	0.0
B	13.4	–69.2
C	42.8	–88.4
D	126.5	–82.5
E	149.0	–50.4
F	118.7	–8.7
G	62.6	–26.9
H	30.9	–4.3

Assignment Sheet 1

Traverse #3: Scale 1″ = 50′

Point	X-Coord.	Y-Coord.
A	0.0	0.0
B	–39.6	–42.4
C	–114.0	–75.6
D	–160.6	–169.1
E	–228.5	–220.2
F	–265.5	–232.6
G	–344.1	–197.6
H	–209.4	–99.8
I	–348.7	–90.1
J	–271.9	–62.2

Traverse #4: Scale 1″ = 200′

Point	X-Coord.	Y-Coord.
A	0	0
B	–104	286
C	–385	0
D	–441	153
E	–652	368
F	–964	55
G	–1383	687
H	–1025	835
I	–730	668
J	–206	1192

Objective 23

Assignment Sheet 2—Lay Out a Survey Alignment for a Road Using Bearings and Coordinates

Name ______________________ Overall Rating __________

Date ______________________

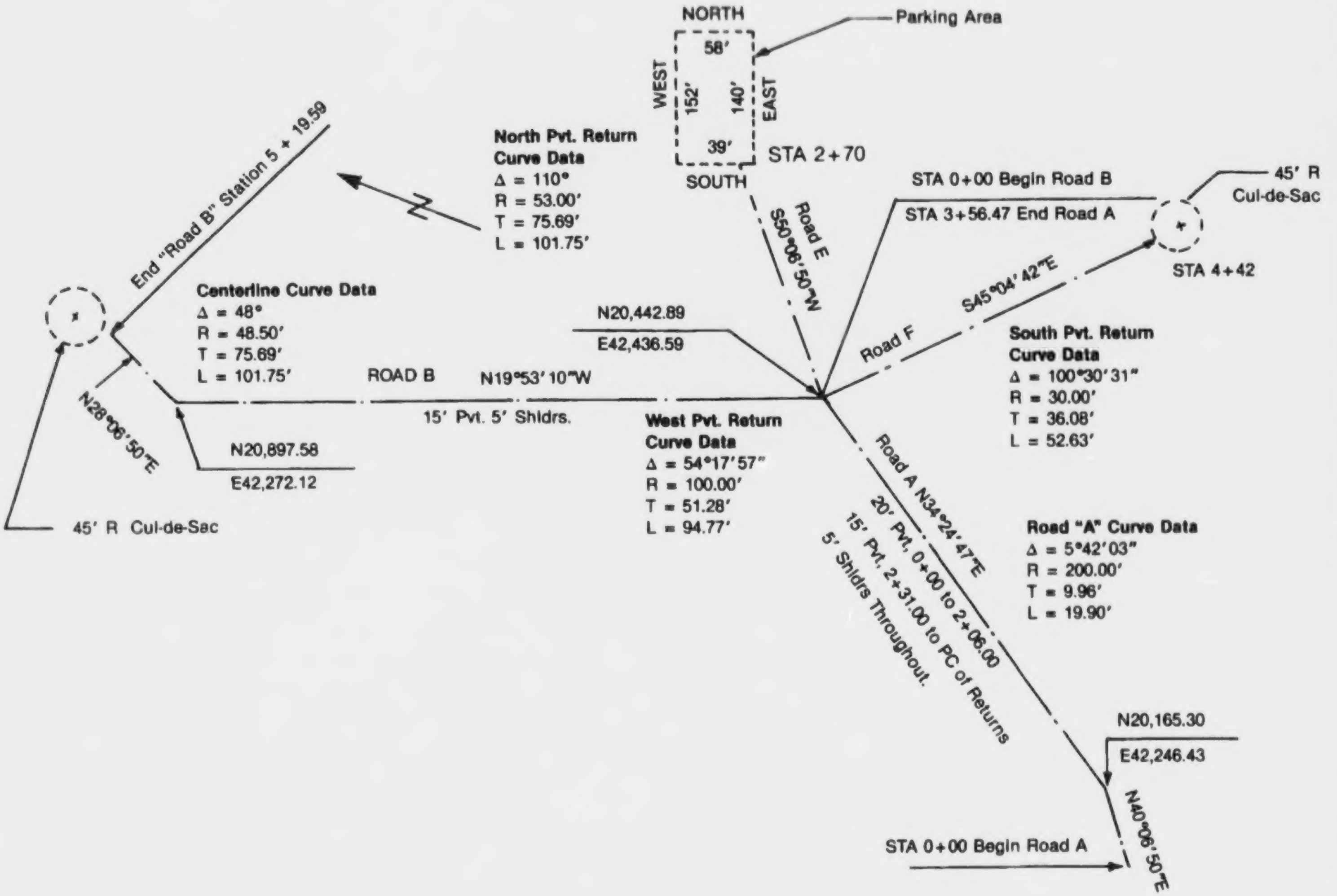
Evaluation Criteria	Rating
• Accuracy of measurement	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics Critical Thinking

Directions

Using the map developed in Unit 6, Assignment Sheet 6, plot the road data included on the following page. Use the same scale used to lay out the other map data. Using the coordinates given on the following sheet, locate the position of the road on the missile site map. Proceed to lay out the road centerline by the given bearings and complete the layout of the road by drafting it onto the final map with the road width and shoulders shown.


NORTH
Parking Area
58'
WEST
152'
140'
EAST
39'
SOUTH
STA 2+70
Road E
S50°06'50"W
North Pvt. Return Curve Data
Δ = 110°
R = 53.00'
T = 75.69'
L = 101.75'
End "Road B" Station 5 + 19.59
Centerline Curve Data
Δ = 48°
R = 48.50'
T = 75.69'
L = 101.75'
N20,442.89
E42,436.59
ROAD B
N19°53'10"W
15' Pvt. 5' Shldrs.
N28°06'50"E
N20,897.58
E42,272.12
45' R Cul-de-Sac
STA 0+00 Begin Road B
STA 3+56.47 End Road A
45' R Cul-de-Sac
STA 4+42
S45°04'42"E
Road F
South Pvt. Return Curve Data
Δ = 100°30'31"
R = 30.00'
T = 36.08'
L = 52.63'
West Pvt. Return Curve Data
Δ = 54°17'57"
R = 100.00'
T = 51.28'
L = 94.77'
Road A N34°24'47"E
20' Pvt, 0+00 to 2+06.00
15' Pvt, 2+31.00 to PC of Returns
5' Shldrs Throughout.
Road "A" Curve Data
Δ = 5°42'03"
R = 200.00'
T = 9.96'
L = 19.90'
N20,165.30
E42,246.43
N40°06'50"E
STA 0+00 Begin Road A

878

877

Objective 24

Assignment Sheet 3—Calculate the Bearing, Slope, % Grade, True Length, and Azimuth of the ℄ of a Highway

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy of measurement	______
• Accuracy of calculations	______
• Assignment is neat and legible	______

Basic Skills

Reading

Mathematics

Critical Thinking

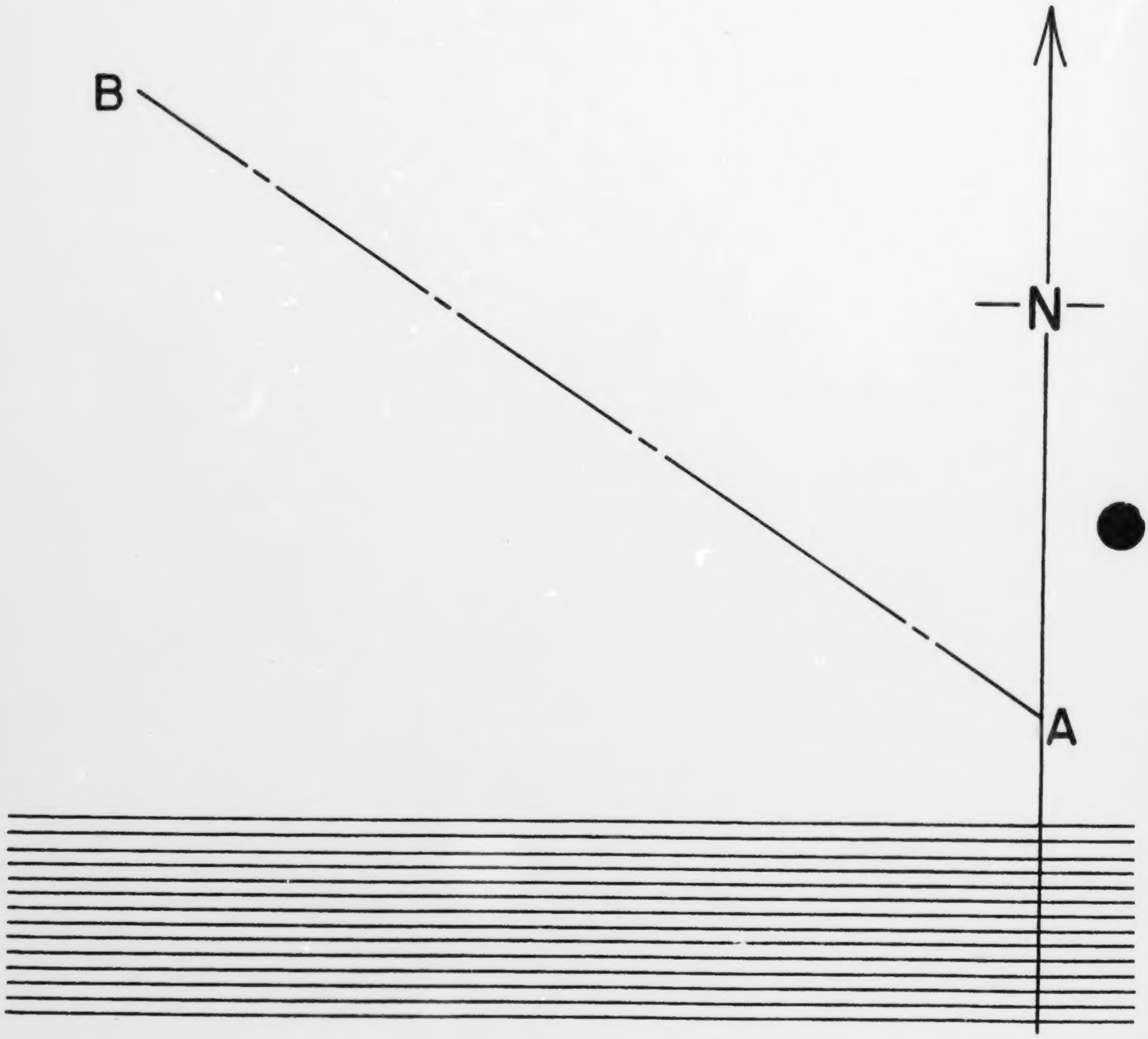
Directions

Line A-B is the center line of a highway. The given map and elevation views may be used to help you.

1. Calculate the following:

   Bearing =
   Slope =
   % Grade =
   True length =
   Azimuth =

2. Shade and label areas of cut and fill.



Scale: 1" = 50"

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Objective 25

Assignment Sheet 4—Develop a Plan and Profile and Cross Sections, and Determine Cut and Fill for a Road Alignment

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy of measurement	______
• Assignment is neat and legible	______

Basic Skills

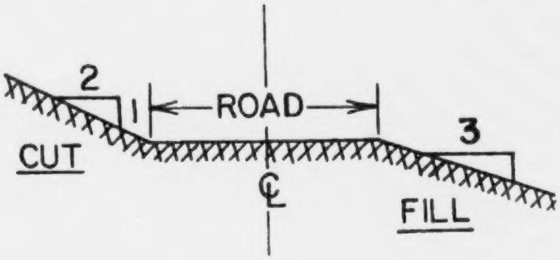
Reading Mathematics Critical Thinking

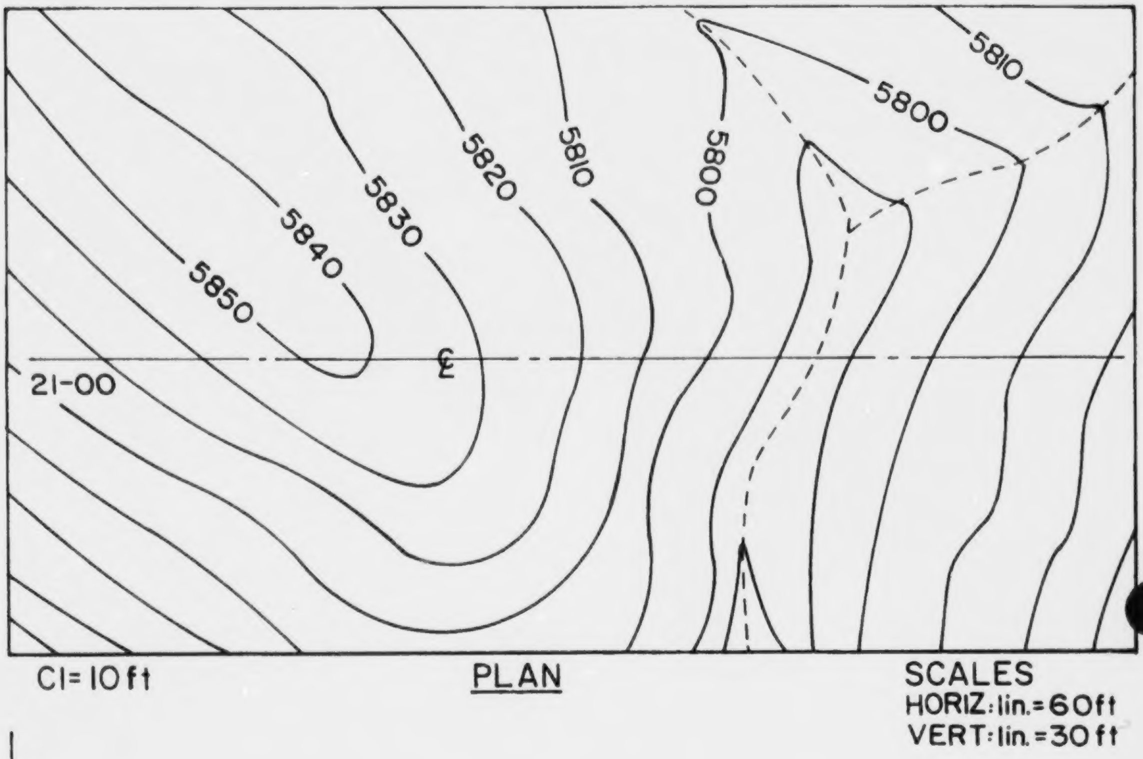
Directions

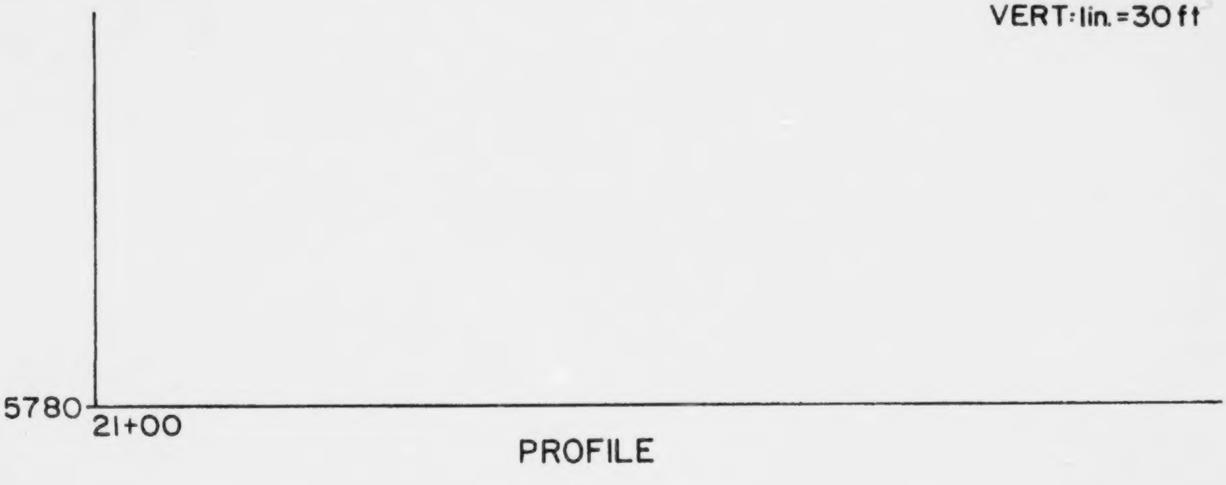
Given Alignment for a road, ____________ ft wide, at a constant elevation of __________ ft, and Sta. 21 + 00

a. Draw road and ground profile. Label centerlines cut and fill for every 50 ft. station. C = cut, F = fill

b. In plan, show cut (shaded) and fill (sectioned). Use typical road section below.




5810
5800
5810
5800
5820
5830
5840
5850
℄
21-00
CI=10ft
PLAN
SCALES
HORIZ: 1in.=60ft
VERT: 1in.=30ft


5780
21+00
PROFILE

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Unit Contents

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2—Draw to Scale a Concrete Engineering Drawing 10–63
3—Detail a Wood Truss 10–67

Objective Sheet

Unit Objective

After completing this unit, the student should be able to prepare detail drawings of structural steel members, draw to scale a concrete engineering drawing, and detail a wood truss. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to structural drafting with their definitions.
2. Define structural drawing.
3. List types of structures.
4. List the four types of materials used for structures.
5. List types of rolled steel products.
6. Match types of steel members with their characteristics and descriptions.
7. Identify structural steel shapes.
8. Select true statements about drawing practices for steel members.
9. Select true statements concerning characteristics of shop drawings.
10. Describe the placement of gage lines for steel members.
11. Complete statements concerning fastener sizes and spacings.
12. Complete statements concerning dimensioning procedures for steel structures.
13. Label a structural steel callout.
14. Select true statements concerning structural steel marking.
15. List steps a structural steel shape goes through in fabrication.
16. Match basic methods for fastening structural steel shapes with their definitions.
17. Match precast concrete abbreviations with their symbols.
18. Identify types of sectional cross section symbols for precast concrete.

Objective Sheet

19. Complete statements concerning anchor bolts used for fastening structural members to concrete footings.

20. Distinguish between the types of concrete.

21. Complete statements concerning the types of concrete reinforcement.

22. Identify standard prestressed concrete units.

23. Match foundation parts with their descriptions.

24. Match types of structural drawings for concrete with their descriptions.

25. Complete a chart of standard symbols and abbreviations for concrete placing drawings.

26. Select true statements concerning standard practices for documentation of rebar.

27. Identify examples of typical details for concrete structures.

28. Complete statements concerning wood construction.

29. Identify types of wood connectors.

30. Identify types of framing connectors.

31. Select true statements concerning components of wood construction.

32. Complete statements concerning heavy timber construction.

33. Prepare detail drawings of structural steel members. (Assignment Sheet 1)

34. Draw to scale a concrete engineering drawing. (Assignment Sheet 2)

35. Detail a wood truss. (Assignment Sheet 3)

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Information Sheet

Objective 1

Terms and definitions

a. **AISC**—American Institute of Steel Construction

b. **Bay**—The space between two consecutive sets or tiers of columns and beams, or columns and trusses

c. **Beam**—A large structural member of concrete, steel, or wood used to support members over openings or from column to column

d. **Bent**—A vertical framework, usually columns and beams supporting other members

e. **Bolt**—A two-piece threaded fastener

f. **Bottom chord**—The main member of a truss running along its lower side between supports and usually carrying tension and bending

g. **Chord**—The top or bottom members of a truss

h. **Clear span**—That horizontal measurement between the inside faces of the two bearings or supports

i. **Column**—A vertical compression member, usually supporting beams and girders, attached to a footing; made of steel, wood, or concrete

j. **Compression**—A force caused by loads being placed on a member that causes a squeezing or shortening effect on the member

k. **Concrete** (as defined by the American Concrete Institute [ACI])—A mixture of portland cement, fine aggregate, coarse aggregate, and water

l. **Cope**—To cut out a part of the top or bottom flange of a beam or channel so that it may fit another

m. **Flange**—The top and bottom projection or outstanding parts of a beam, channel, or girder

n. **Gage line**—The line along which fastener holes are punched or drilled in structural members

o. **Girder**—A large horizontal support member designed to carry bending stress; span from beam to beam

p. **Grout**—A fluid mixture of cement, water, and sand which can be poured to fill small voids or to smooth or level a surface of a wall or footing

q. **Gusset plate**—A plate connecting the several members of a truss or other structural framework

r. **Joist**—A smaller wood or steel floor member that typically spans between girders

s. **Lintel**—A structural member designed to carry the wall over a window, door, or other opening

t. **Mark number**—A system of numbering precast concrete structural members for tracking on a job

u. **Nominal span**—Horizontal distance between the outside edges of supports

v. **Panel**—The space between two purlins in a roof or between two vertical members in a bridge truss

w. **Pin**—A large diameter steel shaft connector similar to a bolt

x. **Prestressed concrete**—Concrete that is precast or cast in place that has wires or cables that are stretched before the concrete is placed around them; the releasing of the wires or cables sets up internal stresses that counteract the external stresses of the applied load to prevent cracking and sagging

y. **Purlin**—The horizontal members spanning from truss to truss, upon which the roof is carried

z. **Rafter**—The wood members used to support the roof in conventional framing

aa. **Rebar**—A short term to define a round, square, or deformed bar used to reinforce concrete

bb. **Smooth bar**—A bar used in slip joints for expansion joints

cc. **Steel member**—A unit part of some larger structure

Example: Floor beam or post in a steel bridge

dd. **Stress**—A unit of force working within a member expressed in pounds per square inch (PSI) acting on structural members due to various types of loads

Note: Forces are torsion, tension, compression, or shear.

ee. **Top chord**—Main member of a truss running along its upper side supporting the decking and usually carrying combined compression and bending

ff. **Truss**—A framed structure consisting of straight members jointed to form a pattern of interconnecting triangles, usually made of wood or metal gg. **Web**—The portion of an I-beam, channel, or girder between the upper and lower flanges

hh. **Weld**—A high temperature process for fusing metal members together

ii. **Working line**—The line where locating dimensions are given

jj. **Working point** (WP)—The edge point where dimensions are given

Example: Intersection of truss member's centerlines

Objective 2

Structural drawing—All layout and detail drawings connected with the design and construction of buildings, bridges, viaducts, and similar structures in which structural steel, timber, concrete, and other building materials are used

Objective 3

Types of structures

a. Buildings

b. Bridges

c. Dams

d. Reinforced concrete foundations

e. Power transmission towers

f. Manholes and vaults

g. Box culverts

h. Retaining walls

i. Signs

Objective 4

Types of materials used for structures

a. Steel

b. Concrete

c. Timber

d. Aluminum

Objective 5

Types of rolled steel products

a. Plate—Flat pieces of steel of various thickness used as a framing product for making changes to framing members; common uses are as stiffener, gusset plates, and creating built-up girders

b. Bars—The smallest steel product and have many cross sectional configurations; round, square, rectangular, or hexagonal; used for modifying other steel framing products

c. Shapes—The main structural steel products: W, M, C, S, T shapes

Objective 6

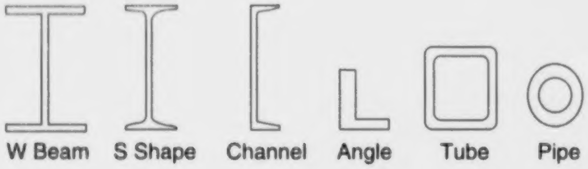
Types of steel members

a. Beams

- Generally are composed of a single piece
- Generally are placed horizontally and are subjected to vertical loads.
- Steel beams are standardized by type of rolled shape and weight.

Figure 1

Example:



- The length of a beam is the extreme dimension as shipped.

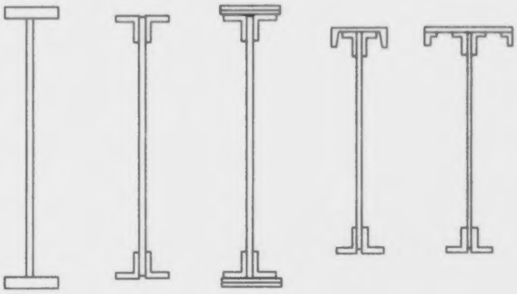
Note: When the connection angles are used at both ends, the length is the distance from back to back of angles.

b. Girders

- Beams made of more than one piece are called plate girders.
- Heavy weight rolled sections that support lighter members are also called girders.
- Are members usually made with a web plate and flanges composed of angles, plates, or both, used to resist bending due to transverse loads

Figure 2

Example:



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c. Columns—Form the principal vertical supports of all steel structures other than bridges and similar spans which rest directly upon masonry and concrete

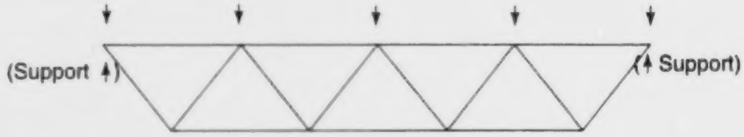
d. Roof trusses

- Are used wherever a comparatively large area is to be covered without immediate columns.
- Web members of an ordinary truss are made of single or double angles with the longer legs vertical.
- Are usually riveted, bolted, or welded in the shop completely or in as large of sections as can be shipped.
- Different members of a truss are connected by means of a gusset plate.

d. Bridge trusses

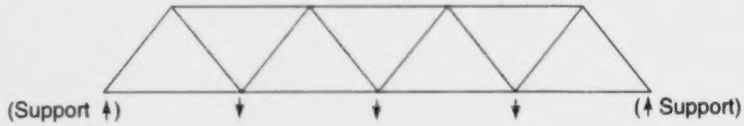
- Deck bridge—The floor load is applied along the upper chord.

Figure 3



- Through bridge—The floor load is applied along the lower chord, and traffic flows through the bridge trusses.

Figure 4



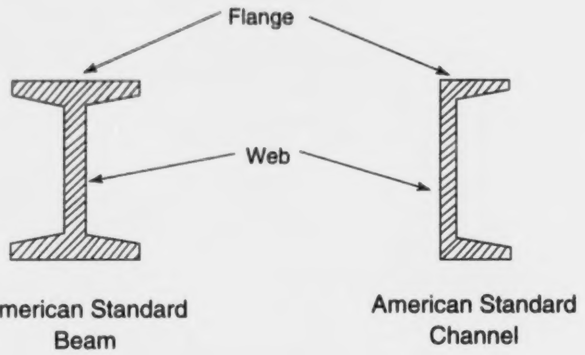
- The joints of a bridge truss may be riveted, welded, bolted, or pin connected.

Objective 7

Structural steel shapes (designations)

a. American standard beam (S): I-beam—Used for beams and struts; has a tapered flange

Figure 5

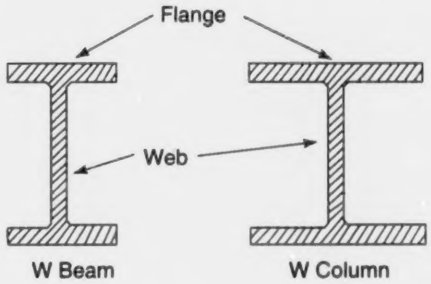

Flange
Web
American Standard Beam
American Standard Channel

b. American standard channels (C)

- Used for struts and in trusses when light loads are required
- Used for steel platforming as load bearing members

c. Wide flange shapes (W)—Used for beams and columns; has uniform thickness flange

Figure 6


Flange
Web
W Beam
W Column

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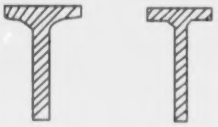
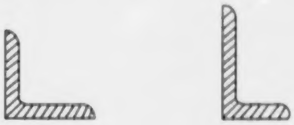
d. Structural tees (WT and ST)— Made by splitting S and W shapes

Figure 7



e. Angles (L)—Used for struts, platforms, cross bracing in trusses, and to add framing strength

Figure 8



Note: Legs of angles may be equal or unequal.

f. Flat bars (bar)—Have a rectangular cross section and are standardly limited to 6″ or 8″ widths

Figure 9

g. Plate (PL or P_L)—Rectangular in cross section; larger than bars; plate widths start at 10″ and are rolled up to 200″ widths depending on thickness; lengths are as long as shipping will allow

Figure 10

h. Floor plate (Floor PL or Floor P_L)—A skid resistant raised pattern on one side used for a walking surface

Note: A full listing of shape designations can be found in the AISC *Manual of Steel Construction.*

Objective 8

Drawing practices for steel members

a. Typical drawing scale

Note: Refer to *Basic Drafting* (MAVCC) for more detailed information on scales.

- Architectural scale
- Engineering scale
- 3/8" = 1'0"—If overall dimensions can be shown on one drawing
- 1/4" = 1'0"—Used for large structures (framing and erection plans)
- No scale—Used for most detail drawings except:
  - 3" = 1'0"—Details of joints
  - 1" or 1 1/2", = 1'0"—Details of trusses

b. Types of structural drawings

- Engineering drawings—Used to provide an overall picture of a job for sales, marketing, estimating or engineering purposes
- Shop drawings—Provide more detail for construction than engineering drawings
- Working drawings—Combined engineering and shop drawings

c. Drawing convention

Note: The drafter works from design layouts or framing plans prepared by architects or designers which show the arrangement of columns, girders, and beams. The detailer prepares a framing or erection layout which may show a plan view, elevation, or both identifying all members with a piece mark. Connections may be omitted and shown as assembly in trusses, columns, beams, and braces.

- Single line drawing—Used when the scale doesn't allow for a lot of detail
  - Steel members are represented by a heavy line.
  - Along the heavy line a double line of the steel member will be placed to clarify angle or flange orientation.

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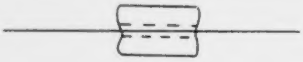
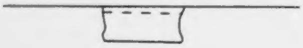
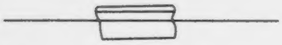
- Single line in plan view represents
  - Centerline of beam



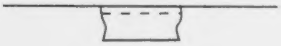
  - Back of channel



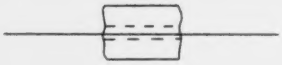
  - Work line of angle bracing



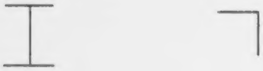
  - Back of angle when used as a beam



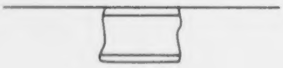
  - Centerline of structural tee



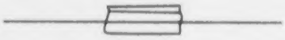
  - Column end view



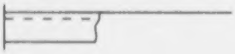
- Single line in elevation view represents
  - Top of beam and channel



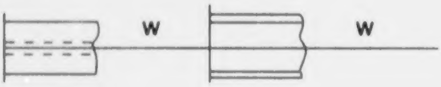
  - Work line of angle or structural tee bracing



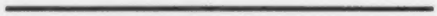
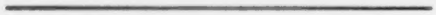
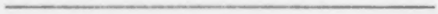
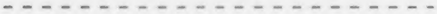
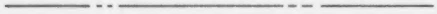
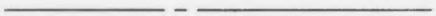
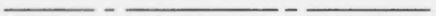
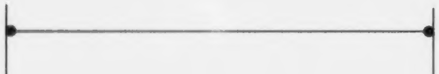
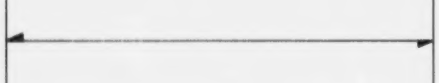
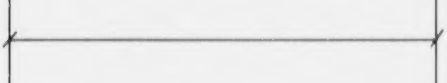
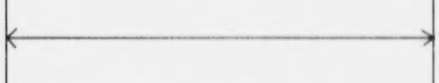
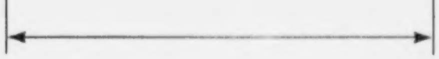
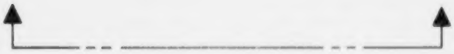
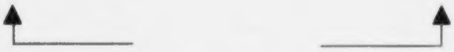
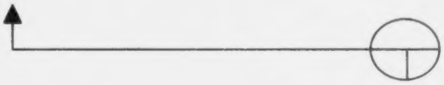
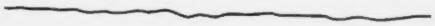
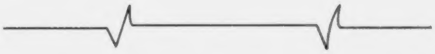
  - Back of angle when used as a beam or column



  - Centerline of wide flange column



d. Commonly used line types in structural drafting

Line Configuration	Line Type
	Object line for heavy emphasis
	Object line for normal emphasis
	Object line for light emphasis or small scale situations
	Hidden line
	Phantom line
	Centerline for short distances
	Centerline for long distances
	Extension line and dimension line with dots
	Extension line and dimension line with half arrowheads
	Extension line and dimension line with slashes
	Extension line and dimension line with open arrowheads
	Extension line and dimension line with standard arrowheads
	Cutting plane line
	Cutting plane line
	Cutting plane line
	Freehand break line
	Mechanical break line

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e. Lettering—An architectural style letter is most commonly used on structural drawings

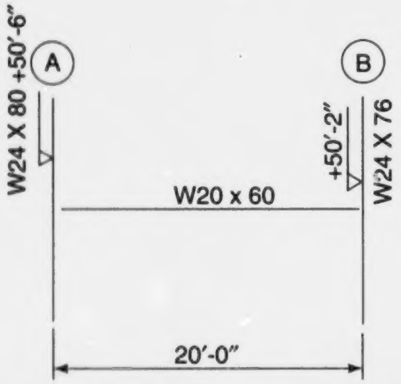
f. Legend—A key to the plan for identification of symbols and abbreviations used on the drawings; usually a master legend is produced for the entire job, rather than for individual sheets

g. Shop bill—A document used to draw from the material that is needed in the fabrication of specific members in a job; may be placed on the drawing or attached to it as a separate form

Objective 9

Characteristics of shop drawings

Figure 12—Shop drawing (Example of a design drawing)



Elevation top of steel shown thus (+50' -6")

Note:
All holes Ø 13/16
All connections to develop full length
unless otherwise specified
Bolts: 3/4 A325
Connecting angles welded to beam,
bolted to support

a. Contains information to set up complete detail drawings

- Length
- Size and type
- Number and type of fasteners
- Precise connection details
- Bill of materials listing every item used in fabrication and erection of final structure

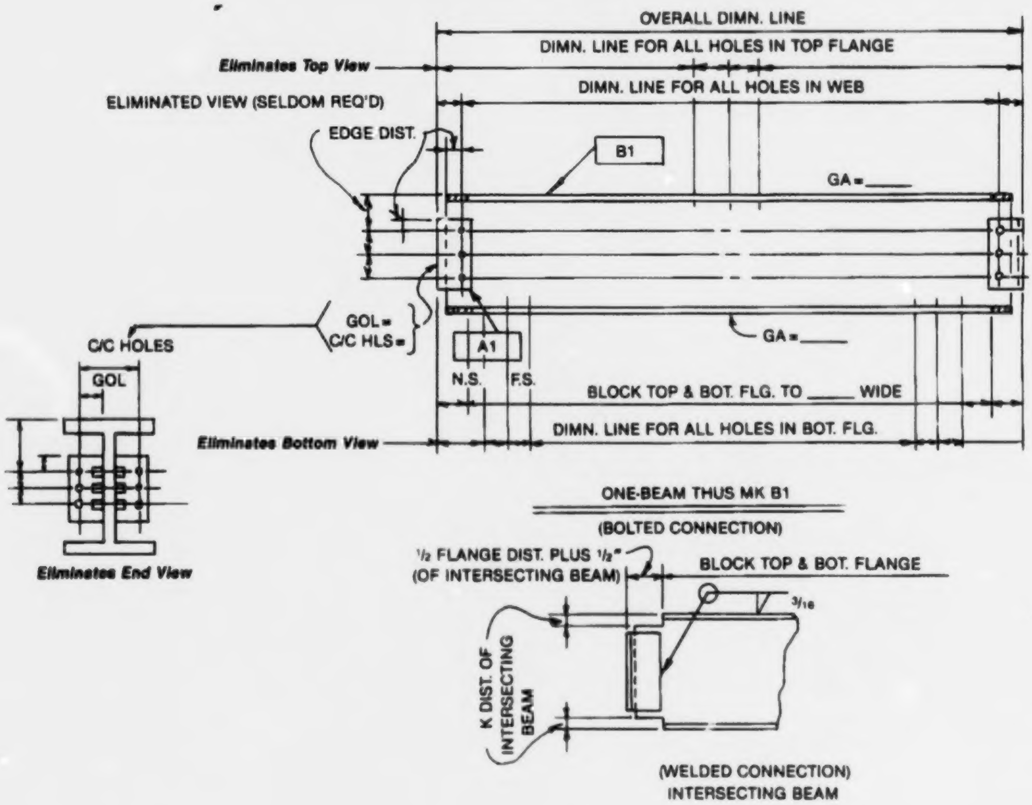
b. Describes the type of construction and end loads

c. Members on shop drawings are presumed to be parallel or at right angles to one another.

d. Elevation view dimensions of beams are generally given as notes on drawings prepared by the designer/architect.

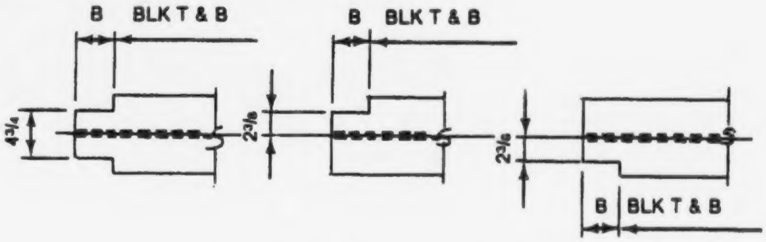
e. Because of industry concern about improving productivity of detailers, a method of special dimensioning practices and notation has been devised to eliminate otherwise necessary views. Examine the following examples describing these techniques.

Figure 13—Beam dimensioning and notation

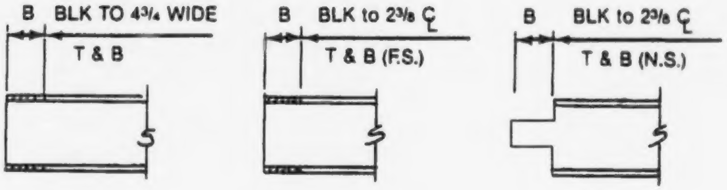

OVERALL DIMN. LINE
DIMN. LINE FOR ALL HOLES IN TOP FLANGE
Eliminates Top View
DIMN. LINE FOR ALL HOLES IN WEB
ELIMINATED VIEW (SELDOM REQ'D)
EDGE DIST.
B1
GA =
GOL =
C/C HLS =
C/C HOLES
GOL
A1
GA =
N.S.
F.S.
BLOCK TOP & BOT. FLG. TO ___ WIDE
Eliminates Bottom View
DIMN. LINE FOR ALL HOLES IN BOT. FLG.
Eliminates End View
ONE-BEAM THUS MK B1
(BOLTED CONNECTION)
½ FLANGE DIST. PLUS ½"
(OF INTERSECTING BEAM)
BLOCK TOP & BOT. FLANGE
3/16
K DIST. OF INTERSECTING BEAM
(WELDED CONNECTION)
INTERSECTING BEAM

NS = Near side gauge line
FS = Far side gauge line
C/C HLS = Center to center holes
GOL = Gauge outside leg

Figure 14—Blocking (coping) of beams


B BLK T & B
B BLK T & B
4¾
2⅜
2⅜
B BLK T & B

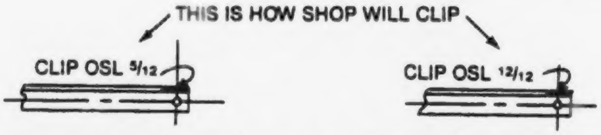
WHEN FLANGE VIEW IS SHOWN


B BLK TO 4¾ WIDE
T & B
B BLK to 2⅜ ℄
T & B (F.S.)
B BLK to 2⅜ ℄
T & B (N.S.)

WHEN WEB VIEW IS SHOWN

Figure 15—Clipping of angles

Only View Required with Notation


THIS IS HOW SHOP WILL CLIP
CLIP OSL 5/12
CLIP OSL 12/12

Clip and backcut angles only when required using 5 to 12 or 12 to 12 bevels. Hold other bevels to a minimum.

f. Symmetrical members

- Large members such as trusses and plate girders are symmetrical about a centerline and only one half is detailed.
- It is standard to detail the left half.
- The detail should be broken past the centerline by a ragged or wavy line.

g. Standard details

- Many steel details have become standardized and the drafter should become familiar with and adhere to these. Standard construction specifications can be found in the *AISC Steel Construction Manual.*
- Many firms have printed forms showing required views of a beam and it is only necessary for the drafter to fill in the dimensions.

Information Sheet

Objective 10

Placement of gage lines—The lines along which fastener holes should be placed in the flanges of I-beams, channels, and angles are standardized

a. Angles—Gage line is measured from the back of the angle

b. Flanges of channels—Gage line is measured from the back of the channel

c. Flanges of I-beams—Gage line is measured from the center

d. Standard gages for I-beams, channels, and angles are located in the *AISC Steel Construction Manual.*

Objective 11

Fastener sizes and spacings

a. Minimum distance for fastener spacing along the gage line has been established by the AISC.

b. The minimum fastener size is governed by the following rule: The diameter of the fastener should never be less than the thickness of the metal punched.

Objective 12

Dimensioning procedures for steel

a. Use aligned method for locating dimensions.

b. Dimensions are in feet and inches and should be placed on top of the dimension line.

c. Longest and overall dimension should be farthest away from the view.

d. The detail dimensions should always be added to see if they check with the overall dimension.

e. Dimensions should be placed no closer than 5/16" apart and the first line should be no closer than double in distance.

f. Dimensions should be given to centerline of beams and backs of angles and channels.

g. Dimensions should be given to the top or bottom of beams and channels, never to both top and bottom.

h. Where a dimension line runs through a hole whose location it does not give, the dimension line should be broken and an arc drawn around the hole.

i. If a particular dimension is for attachment to a column, beam, or equipment to be mounted on the structure, a notation "HOLD" should be indicated next to the dimension.

j. When four or more equal spaces between bolts are required, a note is used such as 4 @ 2 = 8.

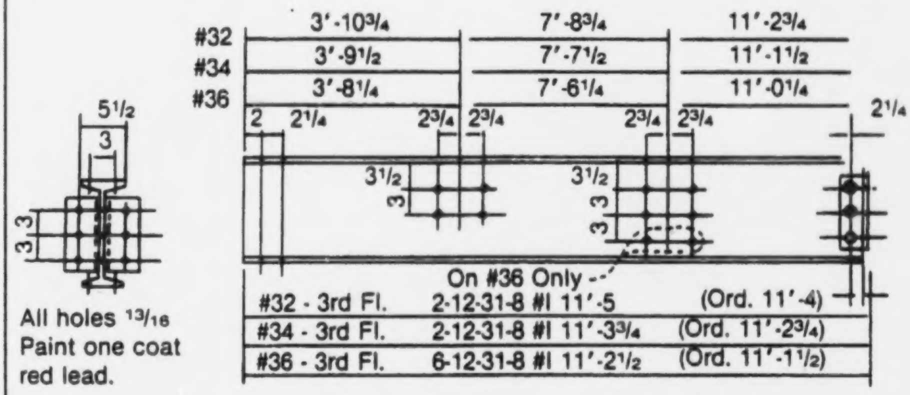
k. Elevation detail dimensions known as levels are usually given as notes on the drawing.

- A reference point is established in the structure, usually top of concrete floor or foundation.
- Elevations above this point are plus values.
- Elevations below this point are minus values.

l. When beams are of the same size and vary only in length, the same drawing can be used for several beams. A set of dimensions for each beam are shown.

Figure 16

Example:

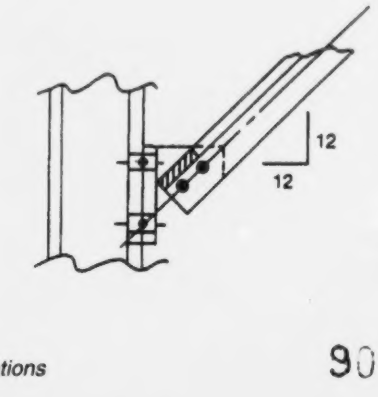

#32
#34
#36
3'-10¾
3'-9½
3'-8¼
7'-8¾
7'-7½
7'-6¼
11'-2¾
11'-1½
11'-0¼
5½
3
3 3
2
2¼
2¾
2¾
2¾
2¾
2¼
3½
3
3½
3 3
On #36 Only
#32 - 3rd Fl. 2-12-31-8 #I 11'-5 (Ord. 11'-4)
#34 - 3rd Fl. 2-12-31-8 #I 11'-3¾ (Ord. 11'-2¾)
#36 - 3rd Fl. 6-12-31-8 #I 11'-2½ (Ord. 11'-1½)
All holes 13/16
Paint one coat
red lead.

m. The slope of all members should be given in rise and run, not angles.

- Run—Horizontal distance
- Rise—Vertical distance

Figure 17

Example:



n. End distances and edge distances are usually given by note on light truss members and dimensioned on beams, columns, and girders.

o. Gage lines should be dimensioned even though they are standard.

p. When lengths of fasteners vary, the various lengths and quantities should be shown at connections on the erection plan, or in a reference list.

q. On truss members, detail dimensions should be placed in a continuous row from end to end of the member with no dimension being omitted.

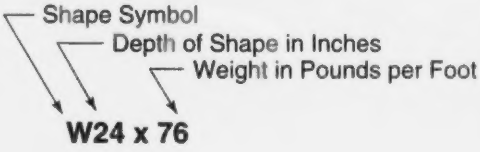
Objective 13

Structural steel callouts

a. Inch designation

Figure 18

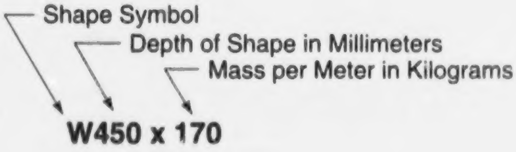
Example:


Shape Symbol
Depth of Shape in Inches
Weight in Pounds per Foot
W24 x 76

b. Metric designation

Figure 19

Example:


Shape Symbol
Depth of Shape in Millimeters
Mass per Meter in Kilograms
W450 x 170

Objective 14

Structural steel marking

a. Marks are used to provide a systematic procedure for detailing, fabricating, and erection.

b. Each member of a structure is given a mark on the design layout.

c. Mark is painted on the piece and used to erect the structure in the field.

d. Each company has its own system of marking.

e. For more information on marking systems, refer to *AISC Structural Steel Detailing*.

Objective 15

Steps a structural steel shape can go through in fabrication

Note: Steps are determined by requirements for delivery and erection.

a. Handling and cutting
b. Punching and drilling
c. Straightening
d. Bending
e. Bolting
f. Riveting
g. Welding
h. Finishing

Objective 16

Basic methods for fastening structural steel shapes

a. Bolting

- Common fastening method, especially utilized in the field
- There are two categories of bolts:
  - Common bolt—Has a square head and is used for limited applications
  - High strength bolt—Classified as A325 and A49

b. Welding—Used for shop connections or permanent field connections

Note: Often bolting and welding are used in combination.

c. Riveting—Until 1950 this was the primary method of fastening steel structures. However, this process is no longer in use and is listed here only because many existing structures still have rivets as their method of fastening.

Objective 17

Precast concrete abbreviations

a. Product abbreviations

BM — Beam
CF — Core floor
COL — Column
DT — Double tee
FS — Flat s[illegible]
ITB — Inverted tee beam
LB — L beam or ledger beam
LT — Lin tee
RB — Rectangular beam
RC — Rectangular column
SqB — Square beam
SqCol — Square column
ST — Single tee
WP — Wall panel

b. Miscellaneous abbreviations and symbols

ab — anchor bolt (aba = anchor bolt-a)
b — blockout (ba = blockout-a)
bp — base plate (bpa = base plate-a)
bearing pad (bpa = bearing pad-a)
cb — connection bolt (cba = conn. bolt-a)
cp — connection plate (cpa = conn. plate-a)
hp — heel plate (hpa = heel plate-a)
tr — threaded rod (tra = threaded rod-a)
wa — weld angle (waa = weld angle-a)
wp — weld plate (wpa = weld plate-a)
#3 Bar — 3/8" Ø Reinforcing bar (#301, 302, 303, etc.)
#4 Bar — 4/8" Ø Reinforcing bar (#401,402, 403, etc.)
#5 Bar — 5/8" Ø Reinforcing bar (#501, 502, 503, etc.)
#6 Bar — 6/8" Ø Reinforcing bar (#601, 602, 603, etc.)
#7 Bar — 7/8" Ø Reinforcing bar (#701, 702, 703, etc.)
#8 Bar — 8/8" Ø Reinforcing bar (#801, 802, 803, etc.)

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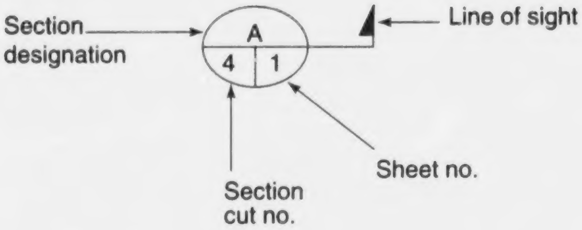
Objective 18

Precast concrete cross section symbols

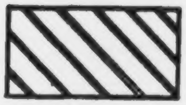
a. Annotated section cutting symbol

Figure 20



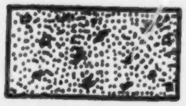
b. Section material symbols

Figure 21



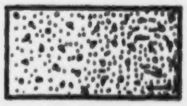
Steel

Figure 22



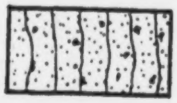
Concrete

Figure 23



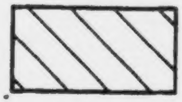
Cinder

Figure 24



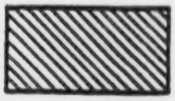
Block

Figure 25



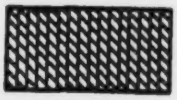
Common brick

Figure 26



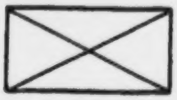
Face brick

Figure 27



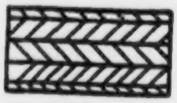
Fire Brick

Figure 28



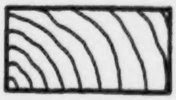
Dimension Lumber

Figure 29



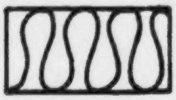
Plywood

Figure 30



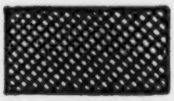
Finish Board

Figure 31



Batt Insulation

Figure 32



Rigid Insulation

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Objective 19

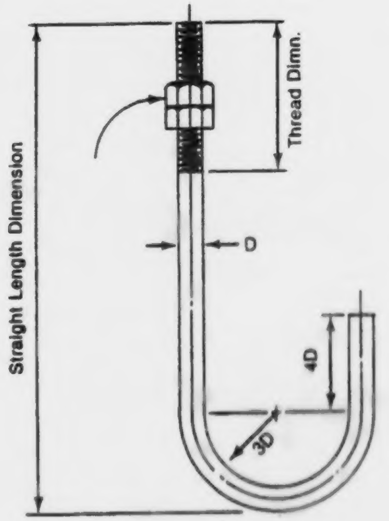
Anchor bolts

a. Used for fastening structural members such as pumps, steel structures, and compressors to concrete foundations/footings

b. Types of anchor bolts

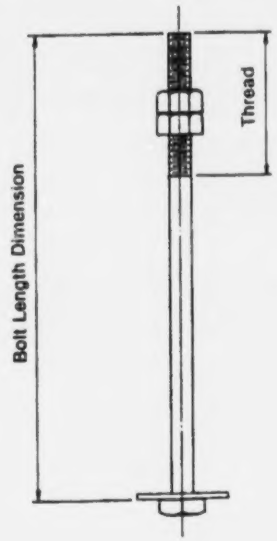
- J-bolt

Figure 33



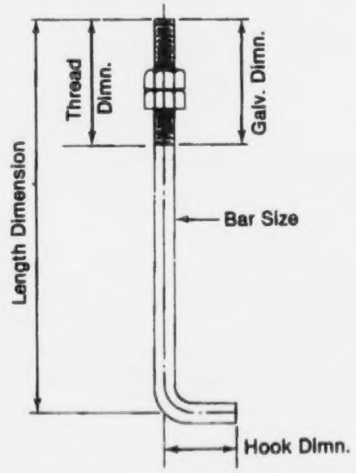
- Machine bolt

Figure 34


Bolt Length Dimension
Thread

- Cane head anchor bolt (C.H.A.B.)

Figure 35


Length Dimension
Thread Dimn.
Galv. Dimn.
Bar Size
Hook Dimn.

c. An alternative to drawing is to call out anchor bolts by diameter size, length, type, and bend dimensions if needed.

Example: An alternative to drawing

( )______ 0 x _______ C.H.A.B., _____"BEND W/HVY HEX NUT AND WASHER

d. Anchor bolt projects above top of grout a dimension equal to the sum of

- Equipment base thickness
- Two anchor bolt diameters for two nuts
- One anchor bolt diameter

Objective 20

Types of concrete

a. Non-reinforced concrete—Has no mesh or reinforcing bars; used for places where only compression stresses occur

Example: Pump foundation

b. Reinforced concrete—Has mesh or steel rebar to help transmit the stresses of compression, tension, and shear forces

Objective 21

Types of concrete reinforcement

a. Reinforcing bar (rebar)

- Identified by number which indicates size in eighths of an inch

  Example: #7 bar–Nominal diameter 7/8″

- Rebar sizes range from #2 to #11 (#14 and #18 – special sizes).
- All rebar is deformed except #2 which is round bar.
- Rebar is made from steel in lengths of 60 feet.

b. Wire mesh (welded wire fabric)

- Used as reinforcement in concrete slabs

  Example: Paving

- Made of deformed wire
- Welded wire fabric (WWF) that is designated by wire spacing and wire gage

  Examples:

  Older Designation

  WWF 6 x 6 - 10/10 - Welded wire fabric, wire spaced six inches each way (6″ square) and #10 gage thick

  Current Designation

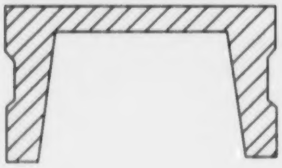
  WWF 6 x 6 W1.4 x W1.4 (W1.4 indicates the area of reinforcing of 0.014 square inches per wire)

Objective 22

Standard prestress concrete units

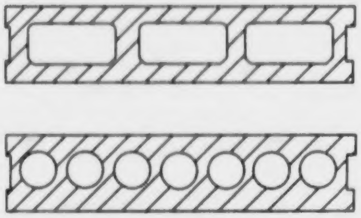
a. Channel slab

Figure 36



b. Wall panels and hollow core slabs

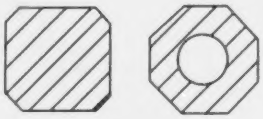
Figure 37



Hollow Core Slabs

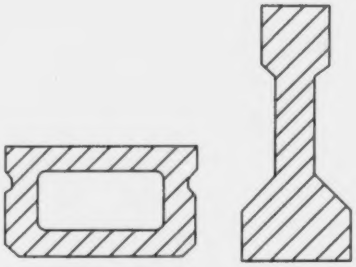
c. Columns and piles

Figure 38



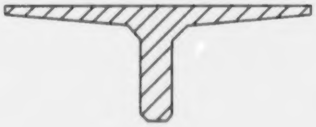
d. Girders

Figure 39

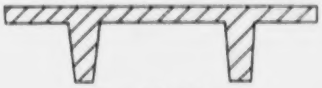


e. Double and single tees

Figure 40



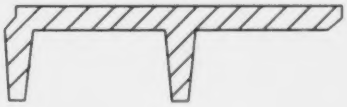
Single Tee



Double Tee

f. Mono-wing ("F") section

Figure 41



g. Blockouts—Openings left in precast members

Objective 23

Foundation parts

a. Pedestal—Rests on the footing and used to support equipment such as pumps; usually stops one foot above grade line

b. Spread footing (footer)—Placed under the pedestal or foundation wall and serves as a bearing member on soil

c. Pier—Generally round 12" to 16" diameter concrete columns poured into drilled (augured) holes in the earth to solid bearing rock when expansive type (clay) soils are encountered. They are placed at 8'0" (max) intervals to support grade beams.

d. Grade beam—Reinforced concrete beam that spans horizontally between piers for support of foundation wall. It replaces the spread footing in expansive soils.

e. Bell-bottomed footing—Used in soil where soil bearing is poor and footing is at a great depth. Belled footing increases the bearing on the soils.

f. Foundation (stem) wall—Used for support of wood framed walls and edge slab support as a method to distribute those loads to a spread footing or grade beam

g. Pilings—Precast, tapered, reinforced concrete shafts driven into the earth to provide support when mass of structure exceeds limits of soil bearing; usually high-rise structures require their use

h. Pilaster—Rectangular-shaped protrusions from masonry walls to provide additional lateral wall support especially where beams intersect the wall

Objective 24

Types of structural drawings for concrete

a. Engineering drawing—Shows where concrete dimensions are but rebar details are omitted

b. Placing drawing—Shows the foundation outline without the outline dimensions but shows all rebar locations and dimensions (used by fabricators and in the field) and bar lists, schedules, and bending details

c. Preprinted drawing—Used for standard details. Drafter needs only to add dimensions, bolt quantity, and size, and assign rebar mark numbers and size.

d. Combined placing and engineering drawing

Note: The ACI standard practice, ACI 315, recommends engineering and placing drawing to be separate, but if a drawing is not too congested, most firms will combine both drawings.

- Rebar placement is shown in the section or elevation.
- Plan view shows engineering dimensions.

e. Framing plans—There are four basic types in precast concrete:

- Column
- Floor/roof
- Beam
- Wall

Objective 25

Standard symbols and abbreviations for concrete placing drawings

a. Symbols

#	To indicate size of deformed bar
ɸ	Plain rounds, as spirals
@	Spacing center to center
⇆	Direction in which bars extend
⟷	Limits of area covered by bars

b. Abbreviations

Bt	Bent	**NF**	Near Face
Bott	Bottom	**OF**	Outside Face
Cl	Clear	**Pl**	Plain Bar
EF	Each Face	**Sp**	Spiral
EW	Each Way	**Stir**	Stirrup
FF	Far Face	**Str**	Straight
IF	Inside Face	**T**	Top

Objective 26

Standard practices for documentation of rebar

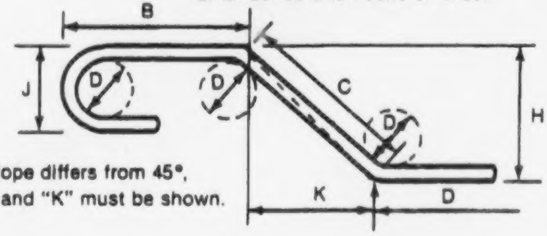
a. Rebar is dimensioned as cut to cut and the bar length is the sum of all detailed dimensions.

b. Rebars are at times bent.

Figure 42

Example:

Unless otherwise noted, diameter D is the same for all bends and hooks on a bar.



Where slope differs from 45°, dimensions "H" and "K" must be shown.

c. Dimensions are to the outside, not centerline of rebar.

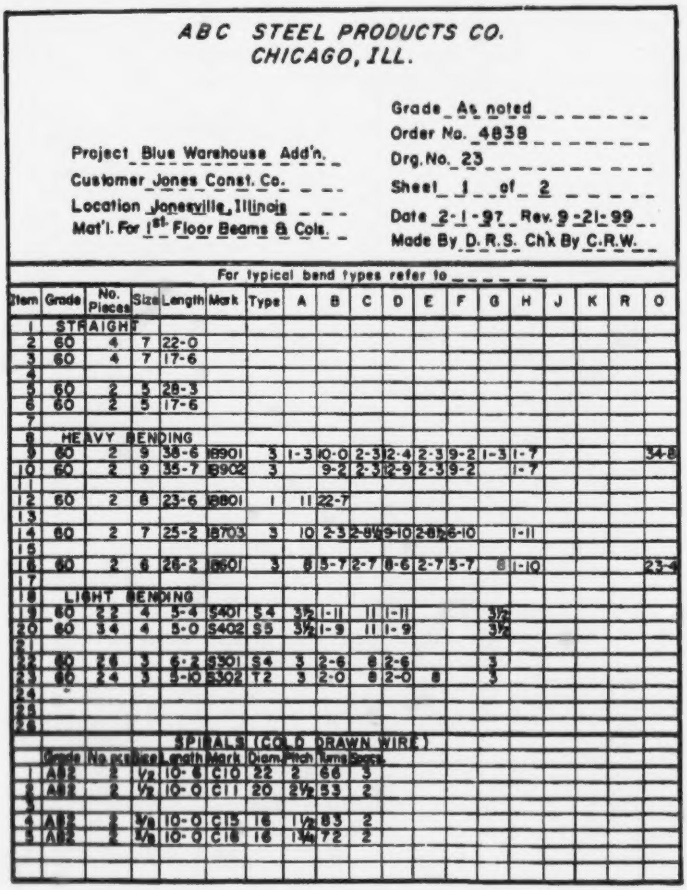
d. Rebar schedules

- Give total length of bar required
- Letter designations are used for dimensions
- Show size, length, and weight of all rebar
- Each bar is marked with an identifying number
  - — Drawing number
  - — Bar size and number

e. Bar schedule must show the number of pieces, size, length, mark of bars, and bending details (a complete summary).

f. Reinforcing bars for foundations, piers, abutments, wing walls, and slabs are usually shown on the plan, section, or elevation.

Figure 43—Typical Bar List



ABC STEEL PRODUCTS CO.
CHICAGO, ILL.

Grade As noted
Order No. 4838
Project Blue Warehouse Add'n.
Drg. No. 23
Customer Jones Const. Co.
Sheet 1 of 2
Location Jonesville, Illinois
Date 2-1-97 Rev. 9-21-99
Mat'l. For 1st Floor Beams & Cols.
Made By D.R.S. Ch'k By C.R.W.

For typical bend types refer to ______

Item	Grade	No. Pieces	Size	Length	Mark	Type	A	B	C	D	E	F	G	H	J	K	R	O
1	STRAIGHT																	
2	60	4	7	22-0														
3	60	4	7	17-6														
4																		
5	60	2	5	28-3														
6	60	2	5	17-6														
7																		
8	HEAVY BENDING																	
9	60	2	9	38-6	18901	3	1-3	10-0	2-3	12-4	2-3	9-2	1-3	1-7				34-8
10	60	2	9	35-7	18902	3		9-2	2-3	12-9	2-3	9-2		1-7				
11																		
12	60	2	8	23-6	18801	1	11	22-7										
13																		
14	60	2	7	25-2	18703	3	10	2-3	2-8½	9-10	2-8½	6-10		1-11				
15																		
16	60	2	6	26-2	18601	3	8	5-7	2-7	8-6	2-7	5-7	8	1-10				23-4
17																		
18	LIGHT BENDING																	
19	60	22	4	5-4	S401	S4	3½	1-11	11	1-11			3½					
20	60	34	4	5-0	S402	S5	3½	1-9	11	1-9			3½					
21																		
22	60	26	3	6-2	S301	S4	3	2-6	8	2-6			3					
23	60	24	3	5-10	S302	T2	3	2-0	8	2-0	8		3					
24																		
25																		
26																		
	SPIRALS (COLD DRAWN WIRE)																	
	Grade	No. pcs	Size	Length	Mark	Diam.	Pitch	Turns	Spacs.									
1	A82	2	½	10-6	C10	22	2	66	3									
2	A82	2	½	10-0	C11	20	2½	53	2									
3																		
4	A82	2	⅜	10-0	C15	16	1½	83	2									
5	A82	2	⅜	10-0	C16	16	1¾	72	2									

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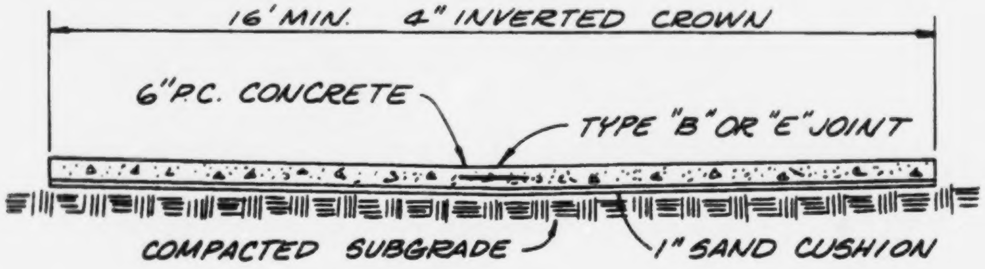
Information Sheet

Objective 27

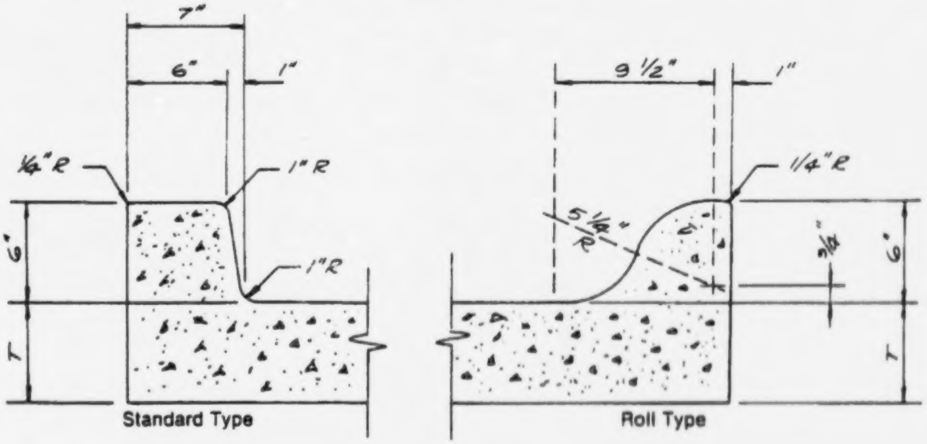
Examples of typical details for concrete structures

a. Highway structures

Figure 44


16' MIN. 4" INVERTED CROWN
6" P.C. CONCRETE
TYPE "B" OR "E" JOINT
COMPACTED SUBGRADE
1" SAND CUSHION

Typical Paving Section for Alley


7"
6"
1"
1/4"R
1"R
1"R
6"
T
9 1/2"
1"
1/4"R
5 1/4" R
3/4"
6"
T

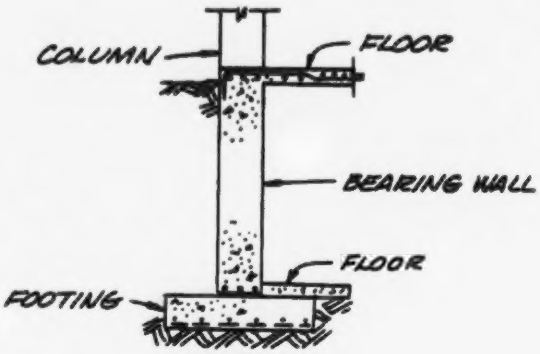
Standard Type

Roll Type

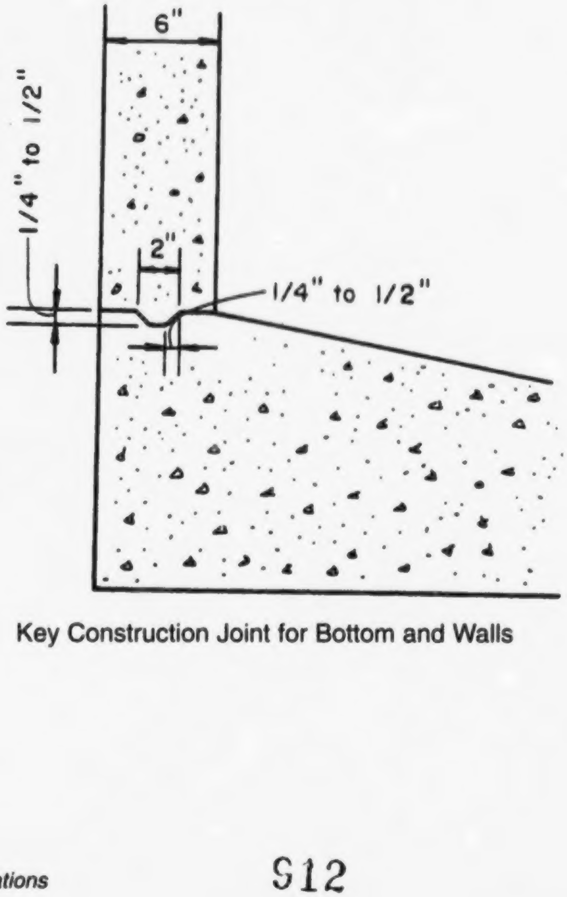
Curb Details

b. Wall structures

Figure 45


COLUMN
FLOOR
BEARING WALL
FLOOR
FOOTING

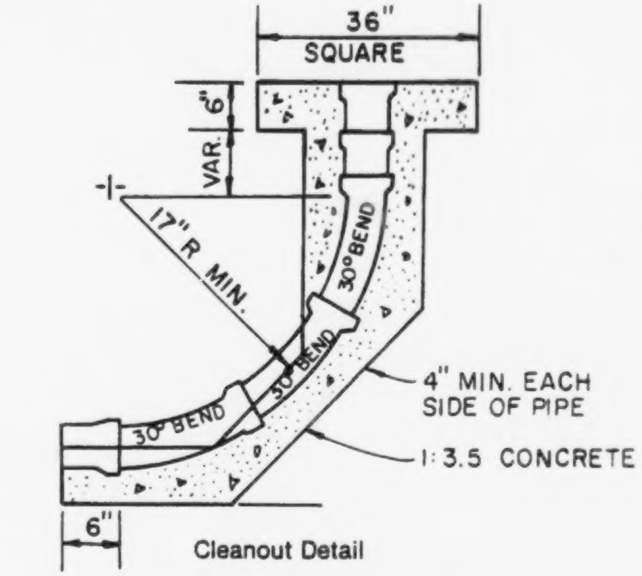
Section of Wall


6"
1/4" to 1/2"
2"
1/4" to 1/2"

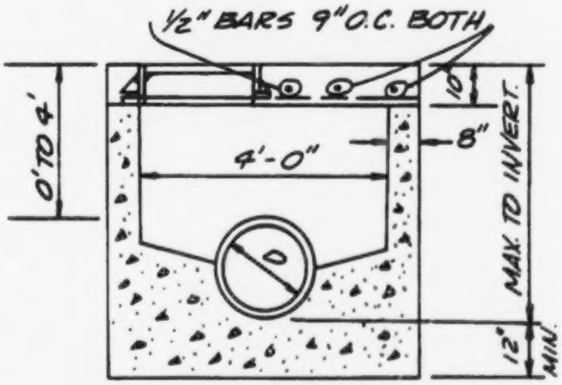
Key Construction Joint for Bottom and Walls

c. Underground structures

Figure 46


36"
SQUARE
6"
VAR.
17" R MIN.
30° BEND
30° BEND
30° BEND
4" MIN. EACH SIDE OF PIPE
1:3.5 CONCRETE
6"

Cleanout Detail


1/2" BARS 9" O.C. BOTH
0' TO 4'
4'-0"
8"
10"
D
MAX. TO INVERT.
12" MIN.

Shallow Manhole

Objective 28

Wood construction (by American Lumber Standards)

a. Timber is lumber five inches or larger in the least dimension generally used for heavy wood members or construction.

b. Lumber is the product of the saw and planning mill.

c. Frame is usually applied to light wood construction.

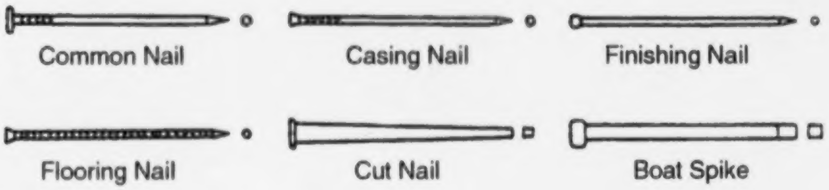
d. Lumber dimensions are called out in nominal size; actual thickness and widths of seasoned and dressed lumber are less than nominal dimensions.

Objective 29

Types of wood connectors

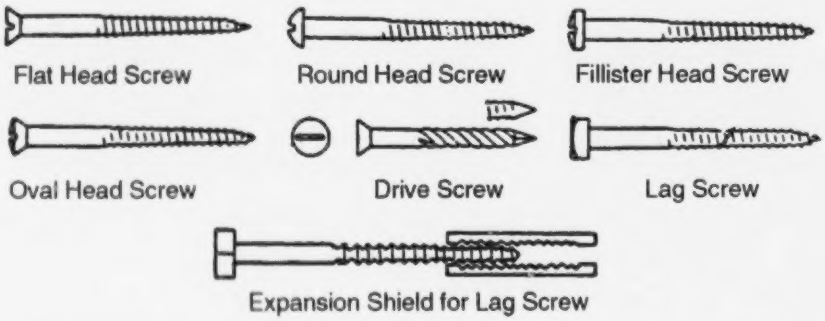
a. Nails

Figure 47


Common Nail
Casing Nail
Finishing Nail
Flooring Nail
Cut Nail
Boat Spike

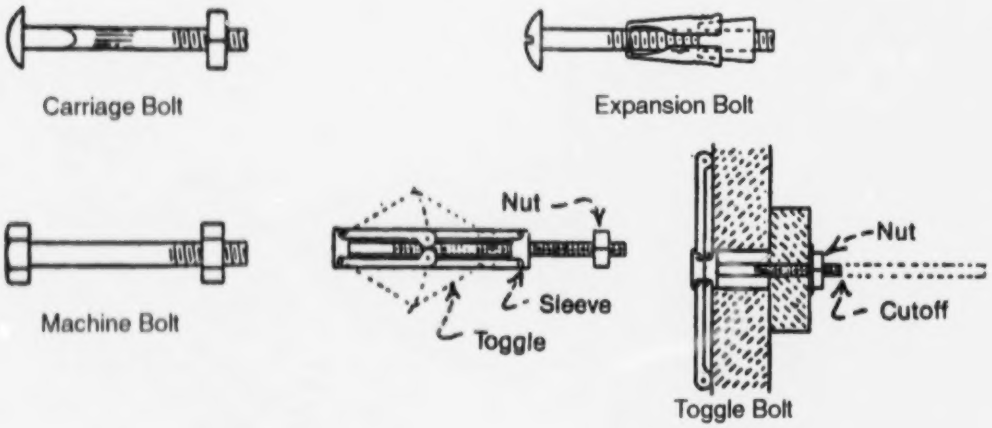
b. Screws

Figure 48


Flat Head Screw
Round Head Screw
Fillister Head Screw
Oval Head Screw
Drive Screw
Lag Screw
Expansion Shield for Lag Screw

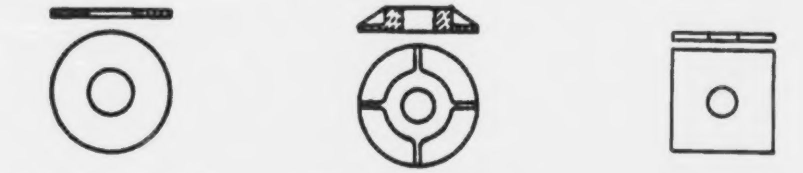
c. Bolts and nuts

Figure 49


Carriage Bolt
Expansion Bolt
Machine Bolt
Nut
Sleeve
Toggle
Nut
Cutoff
Toggle Bolt

d. Washers

Figure 50



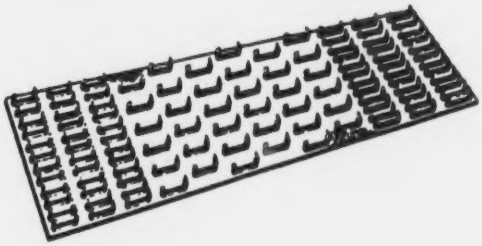
Circular Flat Washer Circular Ribbed Washer Plate Washer

Objective 30

Types of framing connectors

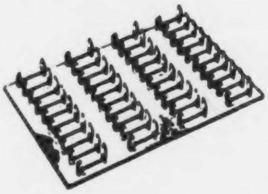
a. Splice plate

Figure 51



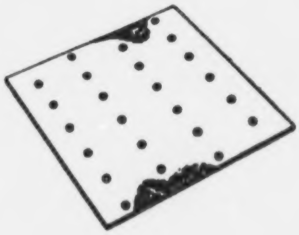
b. Connector

Figure 52



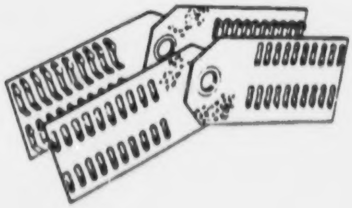
c. Nail plate

Figure 53



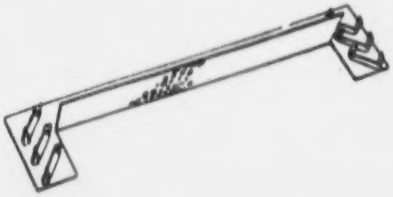
d. Hinge plate

Figure 54



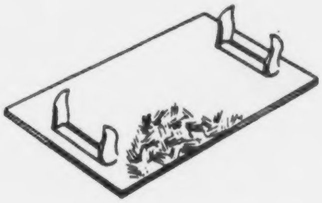
e. Web

Figure 55



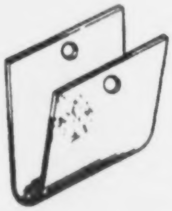
f. Safety plate

Figure 56



g. U-clip

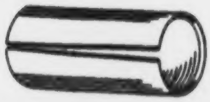
Figure 57



916

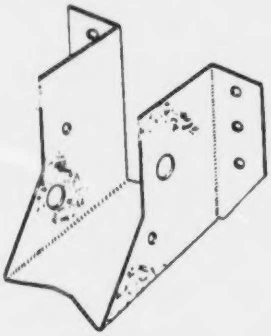
h. Romex

Figure 58



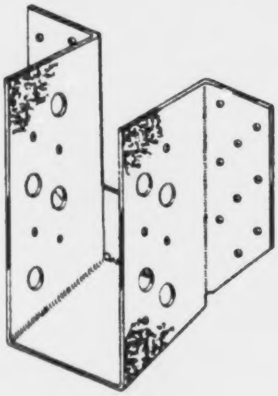
i. Hanger

Figure 59



j. Double member girder hanger

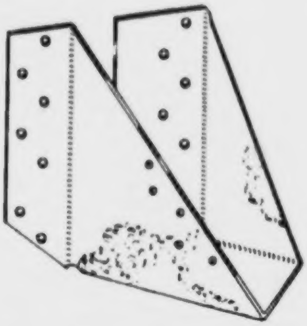
Figure 60



917

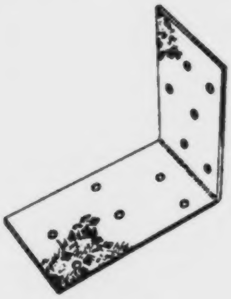
k. 45° hip jack hanger

Figure 61



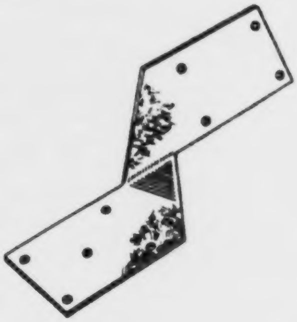
l. 90° angle clip

Figure 62



m. Framing anchor

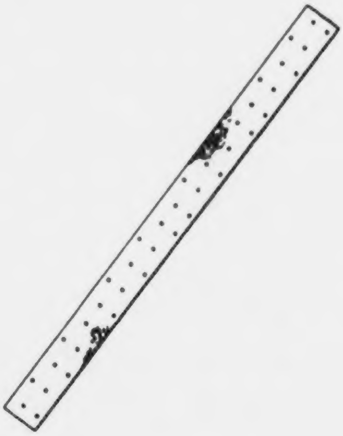
Figure 63



918

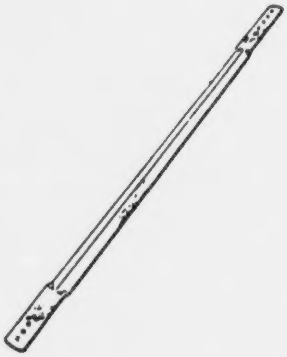
n. Tie down strap

Figure 64



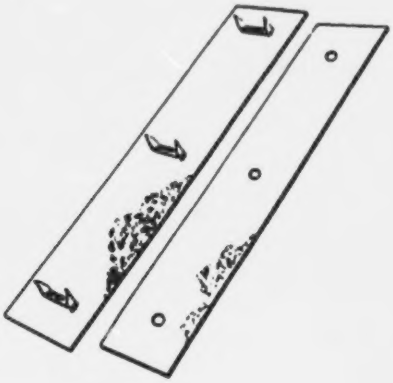
o. Bridging

Figure 65



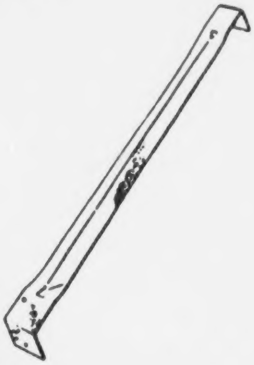
p. Seat plates

Figure 66



q. Truss spacer

Figure 67



Note: The number of connectors required in any joint is determined by the stresses in the members and the properties of the wood.

Information Sheet

Objective 31

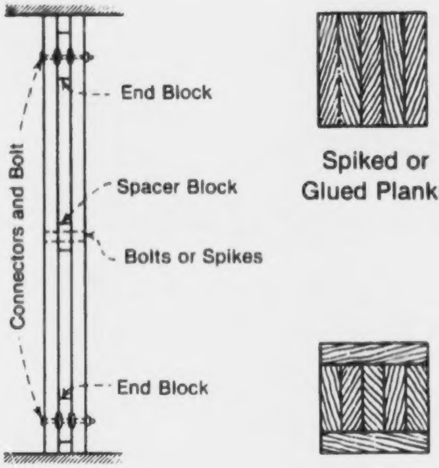
Components of wood construction

a. Columns and studs

- Wood columns are square timbers rarely smaller than 4 x 4 inches and not larger than 12 x 12 inches.
- Columns may be built up of small timbers.

Figure 68

Example:



Spaced Column

Spiked or Glued Planks

Spiked Planks

- Studs—Used for dwellings to carry light loads and receive support from the material attached to them.

b. Wood frame members

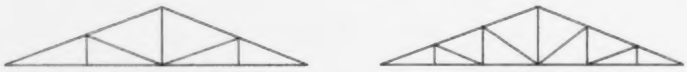
- Types
  - — Floor and ceiling joists
  - — Rafters of sloping roofs
  - — Roof purlins
  - — Beams (plywood, laminated, and trussed)
  - — Girders
- Wood frame construction
  - — Rafter: Common depth of 4″ to 8″
  - — Joists: Common depth of 6″ to 12″ or 14″
- Heavy timber—Minimum thickness permitted for joists, beams, girders, and other members is 6″ and minimum depth is 10″.

c. Wood trusses

- Used to support roofs or floors
- All members, joints, and trusses as a whole should be symmetrical with reference to a vertical plane
- Many types are available

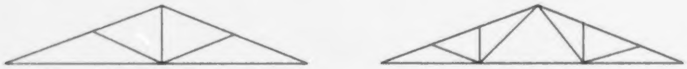
Figure 69

Examples:



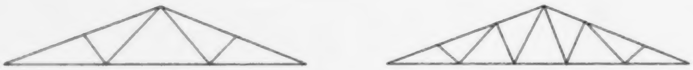
Howe

Double Howe



Fan

Double Fan



Fink

Double W

Objective 32

Heavy timber construction

a. Exterior walls are masonry or other noncombustible materials with a fire resistance rating of at least 2 hours.

b. Interior structural members are heavy timber–solid or laminated.

c. Floors and roofs are heavy plank or laminated wood.

d. Foundation walls are poured–concrete walls on spread foundations.

e. Member sizes are determined by the length of span.

f. First floor framing consists of longitudinal girders.

g. Interior girders are supported by wood columns, pipe, or steel structural shapes.

h. Second floor framing consists of longitudinal girders supported by the walls and the interior columns.

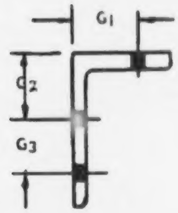
i. Traverse beams span the distance between lines of girders and supported by metal hangers.

j. A tongue-and-groove or a laminated deck may span the space between beams.

Student Supplement 1—Structural Steel Designations

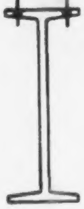
New Designation	Type of Shape	Old Designation
W 24 x 76	W shape	24 WF 76
W 14 x 26		14 B 26
S 24 x 100	S shape	24 [100
M 8 x 18.5	M shape	8 M 18.5
M 10 x 9		10 JR 9.0
M 8 x 34.3		8 x 8 M 34.3
C 12 x 20.7	American Standard Channel	12 [20.7
MC 12 x 45	Miscellaneous Channel	12 x 4 [45.0
MC 12 x 10.6		12 JR [10.6
HP 14 x 73	HP shape	14 BP 73
L 6 x 6 x 3/4	Equal Leg Angle	∠6 x 6 x 3/4
L 6 x 4 x 5/8	Unequal Leg Angle	∠6 x 4 x 5/8
WT 12 x 38	Structural Tee cut from W shape	ST 12 WF 38
WT 7 x 13		ST 7 8 13
ST 12 x 50	Structural Tee cut from S shape	ST 12 I 50
MT 4 x 9.25	Structural Tee cut from M shape	ST M 9.25
MT 5 x 4.5		ST 5 JR 4.5
MT 4 x 17.15		ST 4 M 17.15
PL 1/2 x 18	Plate	PL 18 x 1/2
Bar 1 ◫	Square Bar	Bar 1 ◫
Bar 1 1/4 ⏀	Round Bar	Bar 1 1/4 ⏀
Bar 2 1/2 x 1/2	Flat Bar	Bar 2 1/2 x 1/2
Pipe 4 Std.	Pipe	Pipe 4 Std.
Pipe 4 X-Strong		Pipe 4 X-Strong
Pipe 4 XX-Strong		Pipe 4 XX-Strong
TS 4 x 4 x .375	Structural Tubing: Square	Tube 4 x 4 x .375
TS 5 x 3 x .375	Structural Tubing: Rectangular	Tube 5 x 3 x .375
TS 3 OD x .250	Structural Tubing: Circular	Tube 3 OD x .250

Student Supplement 2—Gage Line Standards



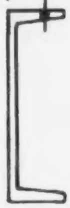
GAGE	LEG SIZE (Inches) 8	6	5	4	$3\frac{1}{2}$	3	$2\frac{1}{2}$	2	$1\frac{3}{4}$	$1\frac{3}{8}$	1
G1	$4\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{8}$	$2\frac{1}{2}$	$2\frac{3}{8}$	$1\frac{3}{4}$	$1\frac{3}{8}$	$1\frac{3}{16}$	1	$\frac{7}{8}$	$\frac{5}{8}$
G2	$3\frac{1}{8}$	$2\frac{3}{8}$	$1\frac{3}{4}$								
G3	$3\frac{1}{8}$	$2\frac{1}{2}$	2								

FLANGE WIDTH	G
$2\frac{3}{8}$ to $2\frac{3}{4}$	$1\frac{1}{2}$
3 to $3\frac{3}{8}$	$1\frac{3}{4}$
$3\frac{1}{2}$ to 4	2
4 to $4\frac{3}{4}$	$2\frac{1}{8}$
5 to $5\frac{3}{4}$	3
6 to $7\frac{1}{4}$	$3\frac{3}{4}$
$7\frac{1}{2}$ to 8	5



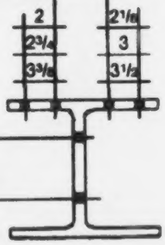
S Shapes

FLANGE WIDTH	G
$1\frac{3}{8}$ to $1\frac{1}{2}$	$\frac{3}{4}$
$1\frac{3}{4}$	1
$1\frac{3}{4}$ to 2	$1\frac{3}{16}$
$2\frac{1}{8}$	$1\frac{3}{16}$
$2\frac{1}{8}$ to $2\frac{3}{8}$	$1\frac{3}{8}$
$2\frac{1}{2}$ to $2\frac{3}{4}$	$1\frac{1}{2}$
$2\frac{7}{8}$ to $3\frac{1}{8}$	$1\frac{3}{4}$
$3\frac{3}{8}$ to $3\frac{5}{8}$	$2\frac{1}{8}$
$3\frac{3}{4}$ to $4\frac{3}{8}$	$2\frac{1}{2}$



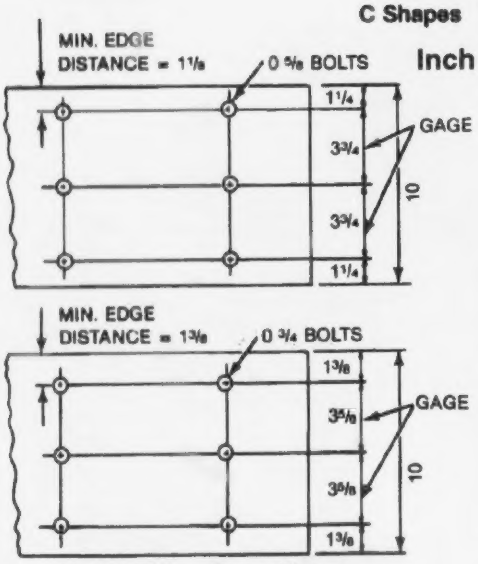
C Shapes

FLANGE WIDTH	G
4	$2\frac{1}{8}$
5 to $5\frac{3}{4}$	3
6 to $7\frac{1}{8}$	$3\frac{3}{4}$
$7\frac{1}{2}$ and Up	$5\frac{1}{8}$


2
$2\frac{3}{4}$
$3\frac{3}{8}$
$2\frac{1}{8}$
3
$3\frac{1}{2}$

DEPTH OF W AND M COLUMN	G
6	$2\frac{1}{8}$
8	$3\frac{3}{4}$
10 to 14	5

Inch Sizes


MIN. EDGE DISTANCE = $1\frac{1}{8}$
Ø $\frac{5}{8}$ BOLTS
$1\frac{1}{4}$
$3\frac{3}{4}$
$3\frac{3}{4}$
$1\frac{1}{4}$
GAGE
10
MIN. EDGE DISTANCE = $1\frac{3}{8}$
Ø $\frac{3}{4}$ BOLTS
$1\frac{3}{8}$
$3\frac{5}{8}$
$3\frac{5}{8}$
$1\frac{3}{8}$
GAGE
10

Establishing Gage Sizes from Edge Distance

	Bolt Diameter	At Sheared Edge	At Rolled or Gas Cut Edge
U.S. Customary (Inches)	$\frac{1}{2}$	1	$\frac{3}{4}$
	$\frac{5}{8}$	$1\frac{1}{8}$	$\frac{7}{8}$
	$\frac{3}{4}$	$1\frac{3}{8}$	1
	$\frac{7}{8}$	$1\frac{1}{2}$	$1\frac{1}{8}$
	1	$1\frac{5}{8}$	$1\frac{3}{16}$
	$1\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{3}{8}$
	$1\frac{1}{4}$	2	$1\frac{1}{2}$
	$1\frac{3}{8}$	$2\frac{1}{2}$	$1\frac{13}{16}$

Minimum Edge Distance for Bolt

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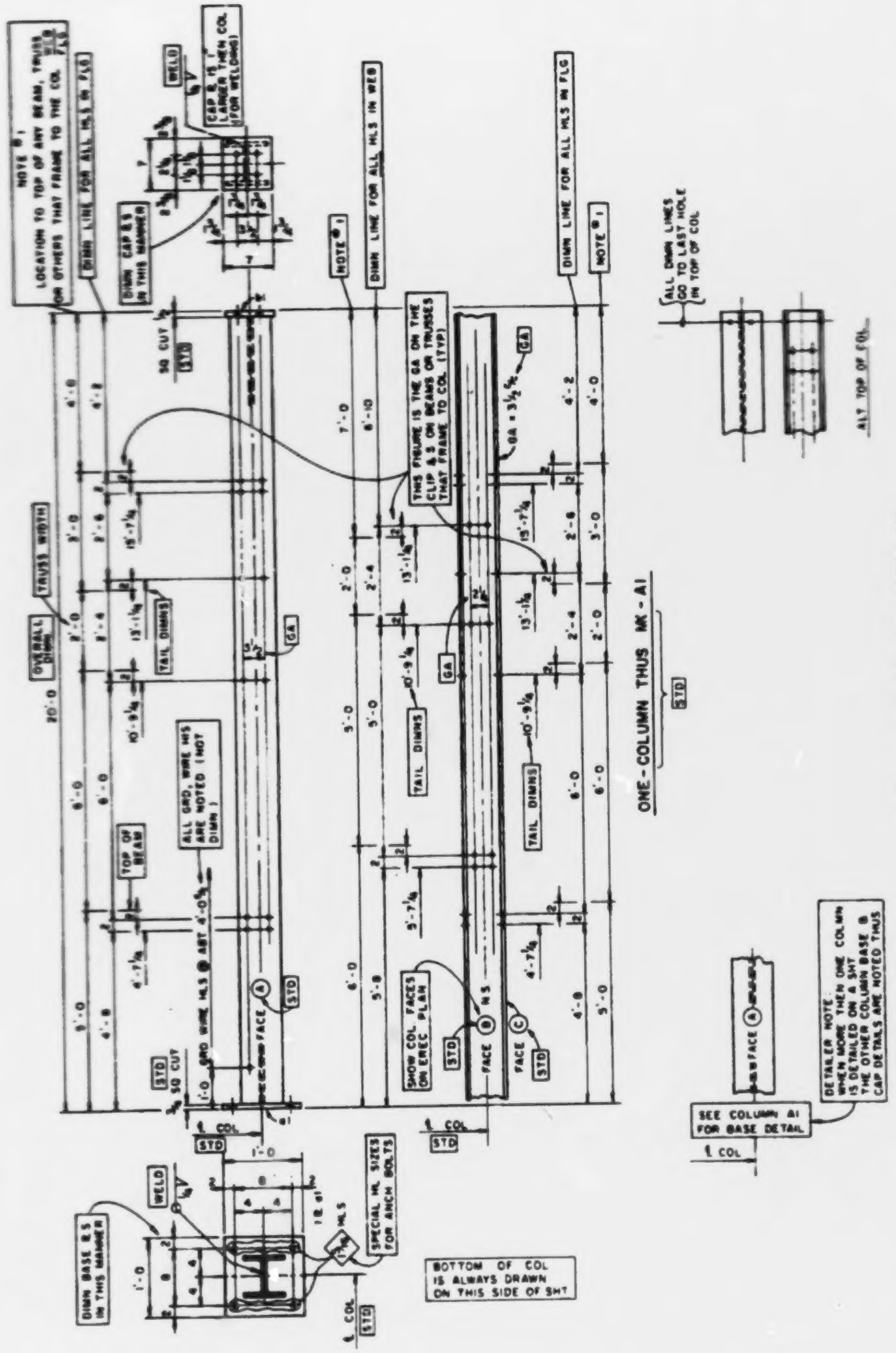
Student Supplement 3—Dimensioning Procedures for Structural Steel


NOTE ®1 LOCATION TO TOP OF ANY BEAM, TRUSS OR OTHERS THAT FRAME TO THE COL WEB/FLG
DIMN LINE FOR ALL HLS IN FLG
OVERALL DIMN
TRUSS WIDTH
20'-0
5'-0
6'-0
2'-0
3'-0
4'-0
4'-8
2'-4
2'-6
4'-2
TOP OF BEAM
4'-7¼
10'-9¼
13'-1⅛
15'-7¼
TAIL DIMNS
DIMN BASE & S IN THIS MANNER
WELD
1'-0
STD
SQ CUT
GRD WIRE HLS @ ABT 4'-0
ALL GRD, WIRE HLS ARE NOTED (NOT DIMN)
FACE Ⓐ
GA
DIMN CAP & S IN THIS MANNER
CAP & IS 1" LARGER THEN COL (FOR WELDING)
℄ COL
HLS
SPECIAL HL SIZES FOR ANCH BOLTS
NOTE ®1
DIMN LINE FOR ALL HLS IN WEB
7'-0
6'-10
5'-8
5'-7¼
SHOW COL FACES ON EREC PLAN
THIS FIGURE IS THE GA ON THE CLIP & S ON BEAMS OR TRUSSES THAT FRAME TO COL (TYP)
BOTTOM OF COL IS ALWAYS DRAWN ON THIS SIDE OF SHT
FACE Ⓑ NS
FACE Ⓒ
GA = 3½
ONE-COLUMN THUS MK-A1
ALL DIMN LINES GO TO LAST HOLE IN TOP OF COL
SEE COLUMN A1 FOR BASE DETAIL
DETAILER NOTE: WHEN MORE THEN ONE COLMN IS DETAILED ON A SHT THE OTHER COLUMN BASE & CAP DETAILS ARE NOTED THUS
ALT TOP OF COL

STANDARD METHOD FOR DETAILING
WF OR B SERIES COLUMNS

Courtesy of Public Service Company of Oklahoma

925 926

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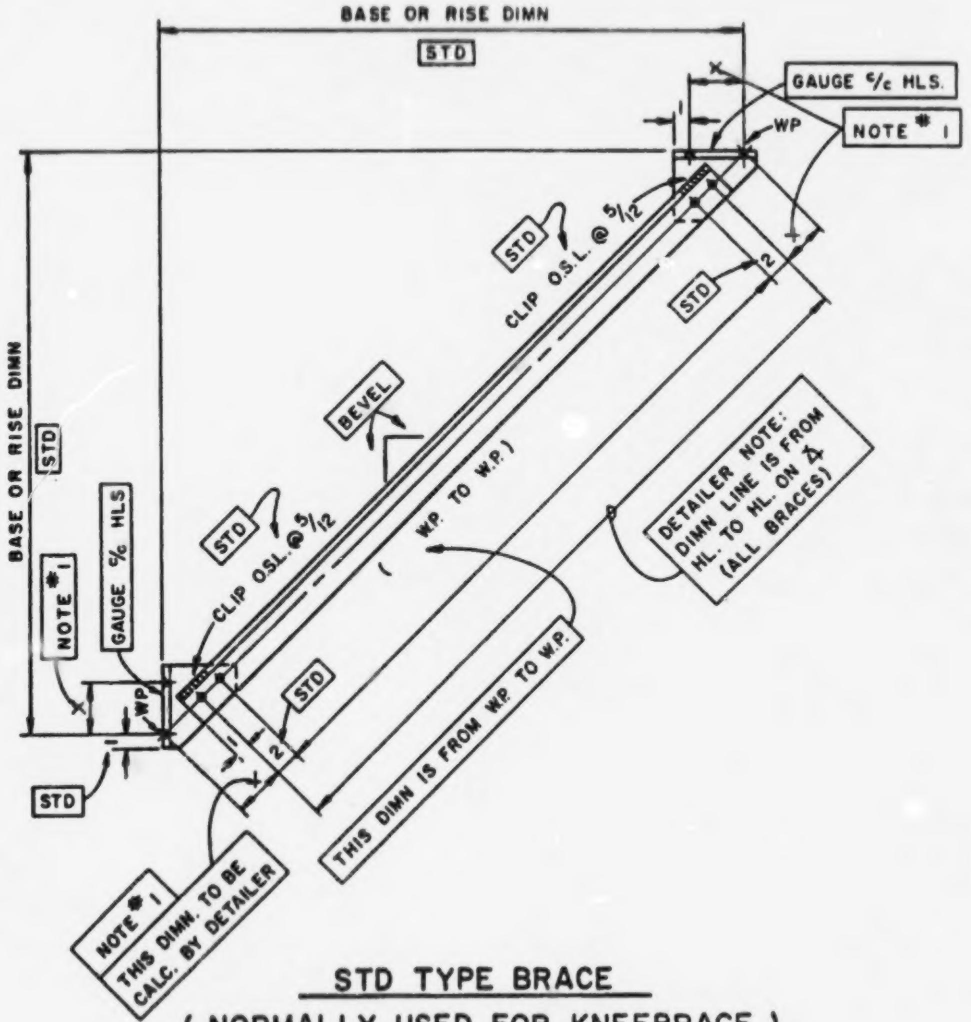
Dimensioning Procedures for Structural Steel (continued)

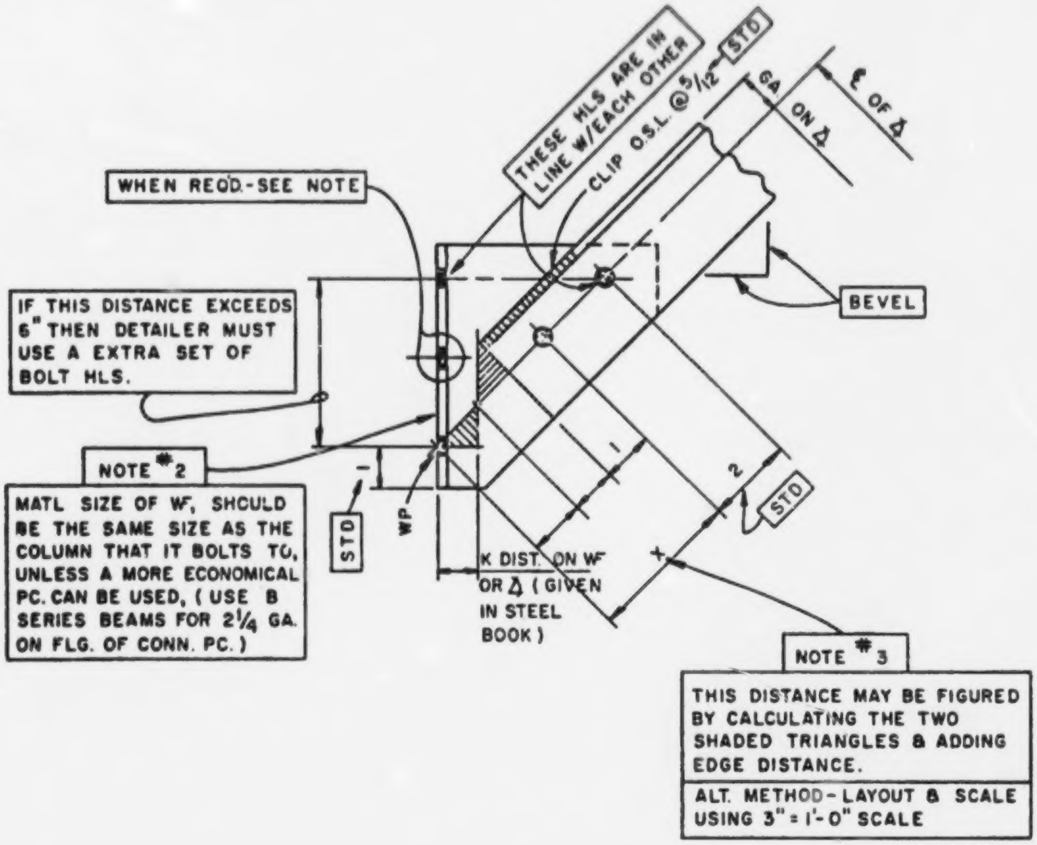

BASE OR RISE DIMN
STD
GAUGE c/c HLS.
WP
NOTE # 1
STD
CLIP O.S.L. @ 5/12
STD
2
BEVEL
STD
CLIP O.S.L. @ 5/12
(W.P. TO W.P.)
DETAILER NOTE: DIMN LINE IS FROM HL. TO HL. ON ℄ (ALL BRACES)
BASE OR RISE DIMN
STD
NOTE # 1
GAUGE c/c HLS
WP
STD
2
STD
THIS DIMN IS FROM W.P. TO W.P.
NOTE # 1
THIS DIMN. TO BE CALC. BY DETAILER

STD TYPE BRACE
(NORMALLY USED FOR KNEEBRACE)

Courtesy of Public Service Company of Oklahoma

027

Dimensioning Procedures for Structural Steel (continued)


THESE HLS ARE IN LINE W/EACH OTHER
CLIP O.S.L. @ 5/12
STD
GA. ON ∆
℄ OF ∆
WHEN REQD.-SEE NOTE
BEVEL
1
2
STD
STD
WP
X
K DIST. ON WF OR ∆ (GIVEN IN STEEL BOOK)

IF THIS DISTANCE EXCEEDS 6" THEN DETAILER MUST USE A EXTRA SET OF BOLT HLS.

NOTE #2

MATL SIZE OF WF, SHOULD BE THE SAME SIZE AS THE COLUMN THAT IT BOLTS TO, UNLESS A MORE ECONOMICAL PC. CAN BE USED, (USE B SERIES BEAMS FOR 2¼ GA. ON FLG. OF CONN. PC.)

NOTE #3

THIS DISTANCE MAY BE FIGURED BY CALCULATING THE TWO SHADED TRIANGLES & ADDING EDGE DISTANCE.

ALT. METHOD - LAYOUT & SCALE USING 3" = 1'-0" SCALE

DETAIL NO. 1

THE ABOVE METHOD SHOWS HOW TO CALCULATE THE DIMN FOR THE CONNECTING PC. OF A BRACE. THE CONNECTING PC. MAY BE AN ANGLE OR WF (USE WF WHERE POSSIBLE.) BUT BOTH CAN BE FIGURED THE SAME WAY.

Courtesy of Public Service Company of Oklahoma

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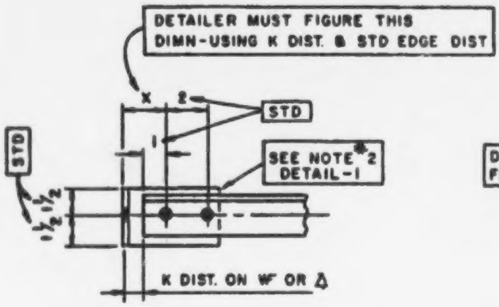
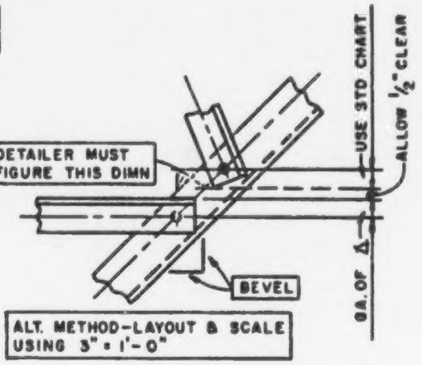
Dimensioning Procedures for Structural Steel (continued)

DRAFTING REFERENCE MANUAL


DETAILER MUST FIGURE THIS DIMN-USING K DIST. & STD EDGE DIST

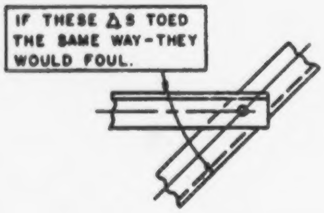
SEE NOTE *2 DETAIL-1
X
2
STD
1
STD
1½
1½
K DIST. ON W OR ∠

DETAIL NO. 2

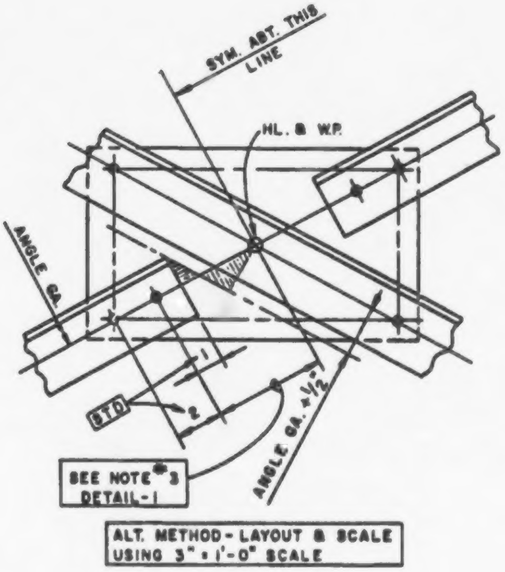

DETAILER MUST FIGURE THIS DIMN

ALT. METHOD-LAYOUT & SCALE USING 3" = 1'-0"
USE STD CHART
ALLOW ½" CLEAR
BEVEL
GA. OF ∠

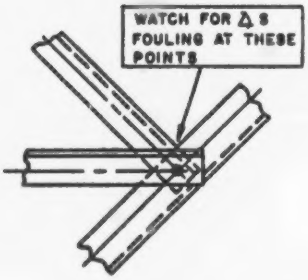
DETAIL NO. 3


IF THESE ∠S TOED THE SAME WAY-THEY WOULD FOUL.

DETAIL NO. 4


SEE NOTE *3 DETAIL-1

ALT. METHOD - LAYOUT & SCALE USING 3" = 1'-0" SCALE
SYM. ABT. THIS LINE
HL. & W.P.
ANGLE GA.
STD
1
2
ANGLE GA. + ½"


WATCH FOR ∠S FOULING AT THESE POINTS

DETAIL NO. 5

DETAIL NO. 6

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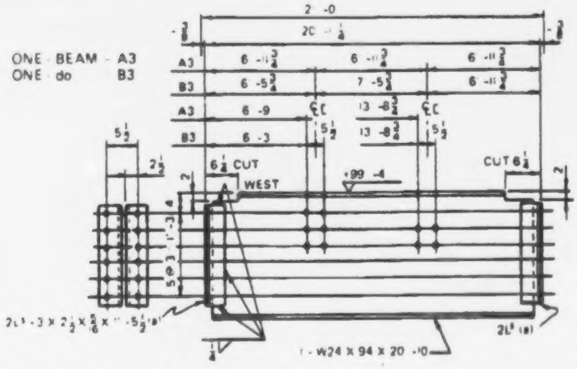
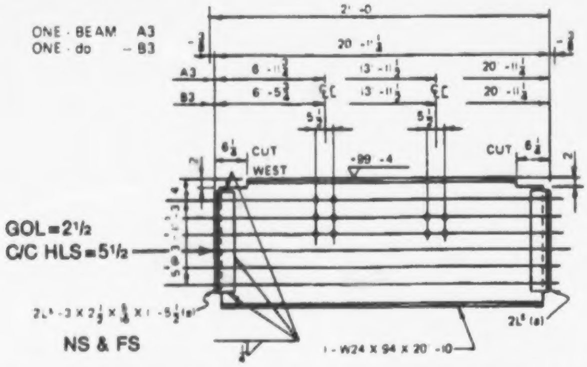
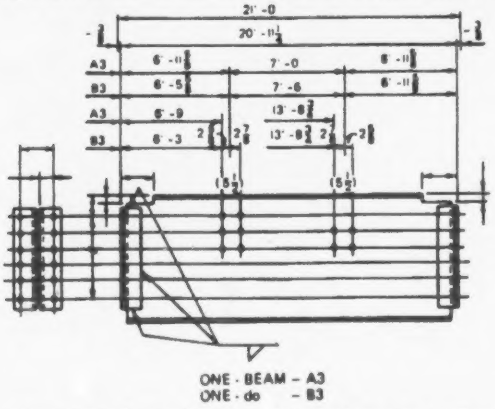
Student Supplement 4—Dimensioning Beam Channels


2 -0
20 -11¼
ONE - BEAM - A3
ONE - do B3
A3
B3
A3
B3
6 -11¾
6 -11¾
6 -11¾
6 -5¾
7 -5¾
6 -11¾
6 -9
13 -8¾
6 -3
13 -8¾
5½
2½
6¼ CUT
WEST
+99 -4
CUT 6¼
2L¹ -3 x 2½ x 5/16 x 1' -5½ (a)
2L¹ (a)
1 - W24 x 94 x 20 -10

Dimensioning to Centerline of Channel Webs and Centerline of Holes from Left End of Beam


2' -0
ONE - BEAM A3
ONE - do - B3
20 -11¼
A3
B3
6 -11¾
6 -5¾
13 -11½
13 -11½
20 -11¼
20 -11¼
5½
5½
6¼ CUT
WEST
+99 -4
CUT 6¼
GOL=2½
C/C HLS=5½
2L¹ -3 x 2½ x 5/16 x 1' -5½ (a)
NS & FS
2L¹ (a)
1 - W24 x 94 x 20 -10

Dimensioning from the Left End of Beam to Centerline of Channel Webs


21' -0
20' -11¼
A3
B3
A3
B3
6' -11¾
7' -0
6' -11¾
6' -5¾
7' -6
6' -11¾
6' -9
13' -8¾
6' -3
13' -8¾
(5½)
(5½)
ONE - BEAM - A3
ONE - do - B3

Dimensioning to Centerline of Holes with Reference to Backs of Channels

Courtesy of Public Service Company of Oklahoma

930

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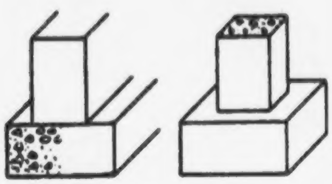
Standard ASTM A-305 Reinfor			
Bar Size Number	Weight # Per Foot	Diameter Inches	C Ar
2	0.167	0.250	
3	0.376	0.375	
4	0.668	0.500	
5	1.043	0.625	
6	1.502	0.750	
7	2.044	0.875	
8	2.670	1.000	
9	3.400	1.128	
10	4.303	1.270	
11	5.313	1.410	
Special ASTM A-408 Reinforci			
14S	7.65	1.693	
18S	13.60	2.257	

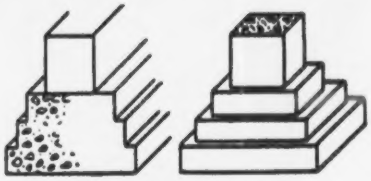
Student Supplement 5—Rebar Data

TM A-305 Reinforcing Bars		
eter hes	Cross Sectional Area, Sq. Inches	Perimeter, Inches
250	0.05	0.786
375	0.11	1.178
500	0.20	1.571
625	0.31	1.963
750	0.44	2.356
875	0.60	2.749
000	0.79	3.142
128	1.00	3.544
270	1.27	3.990
410	1.56	4.430
TM A-408 Reinforcing Bars		
693	2.25	5.32
257	4.00	7.09

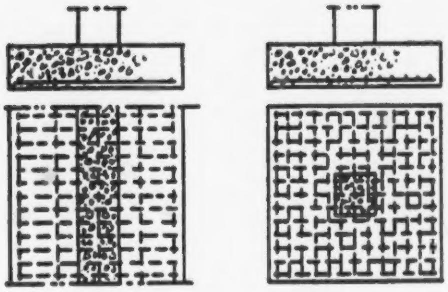
Student Supplement 6—Examples of Foundation Parts



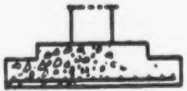
Simple Footings



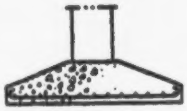
Plain Stepped Footings



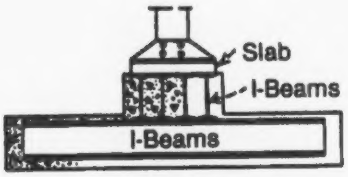
Slab Footings



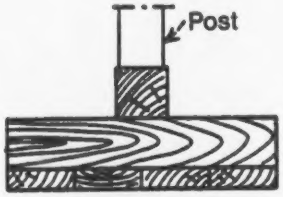
Stepped



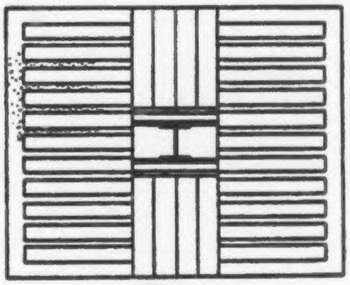
Sloped



Elevation



Timber Grillage Footing

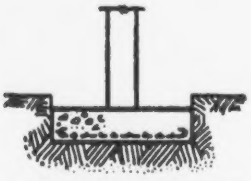


Plan

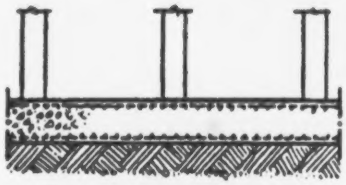
Steel Grillage Footing

Student Supplement 6

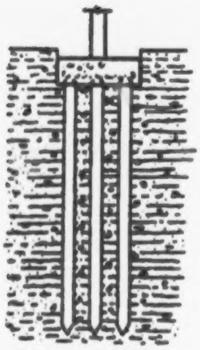
Examples of Foundation Parts (continued)



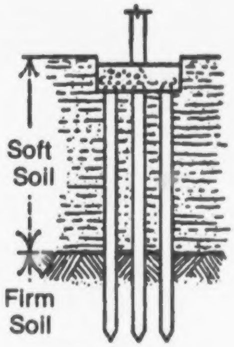
Reinforced Concrete Column Footing



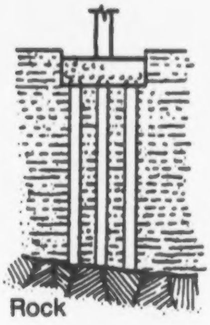
Reinforced Concrete Mat or Raft



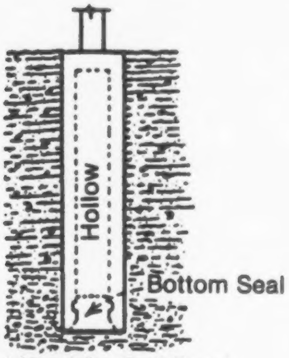
Piles in Soil


Soft Soil
Firm Soil

Piles through Soft Soil into Firm Soil

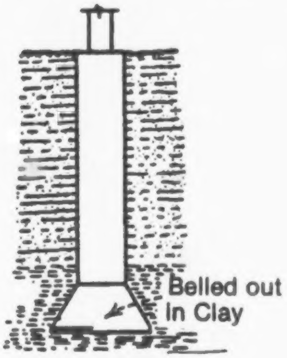


Piles Bearing on Rock

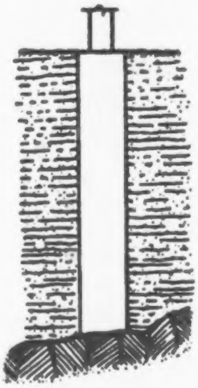

Hollow
Bottom Seal

(Not Used for Buildings)

Piles in Soil

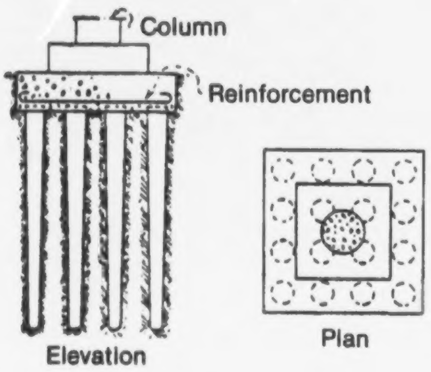

Belled out In Clay

Piers on Firm Clay or Hardpan

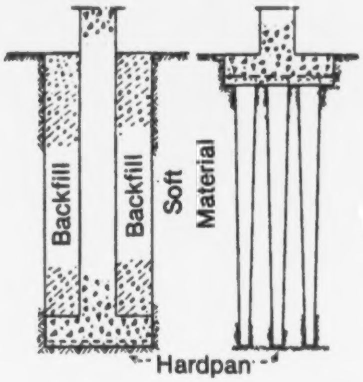


Piers on Rock

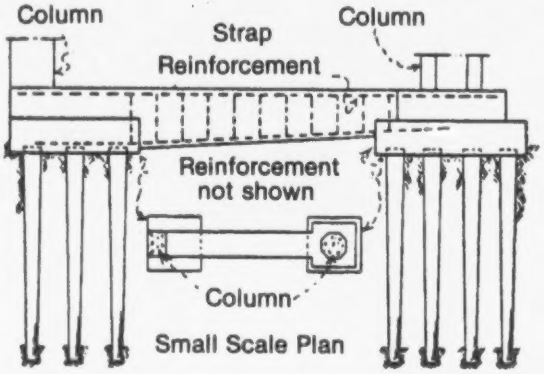
Examples of Foundation Parts (continued)


Column
Reinforcement
Elevation
Plan

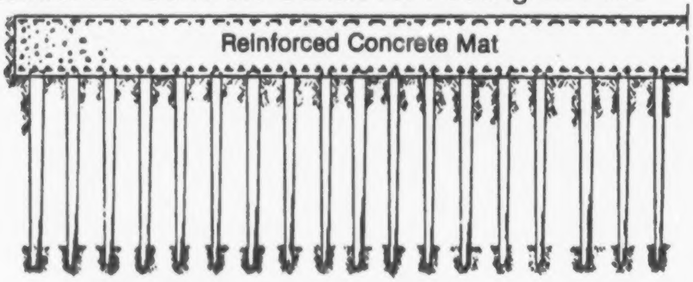
Footing on Piles


Backfill
Backfill
Soft Material
Hardpan

Use of Piles to Carry Footing

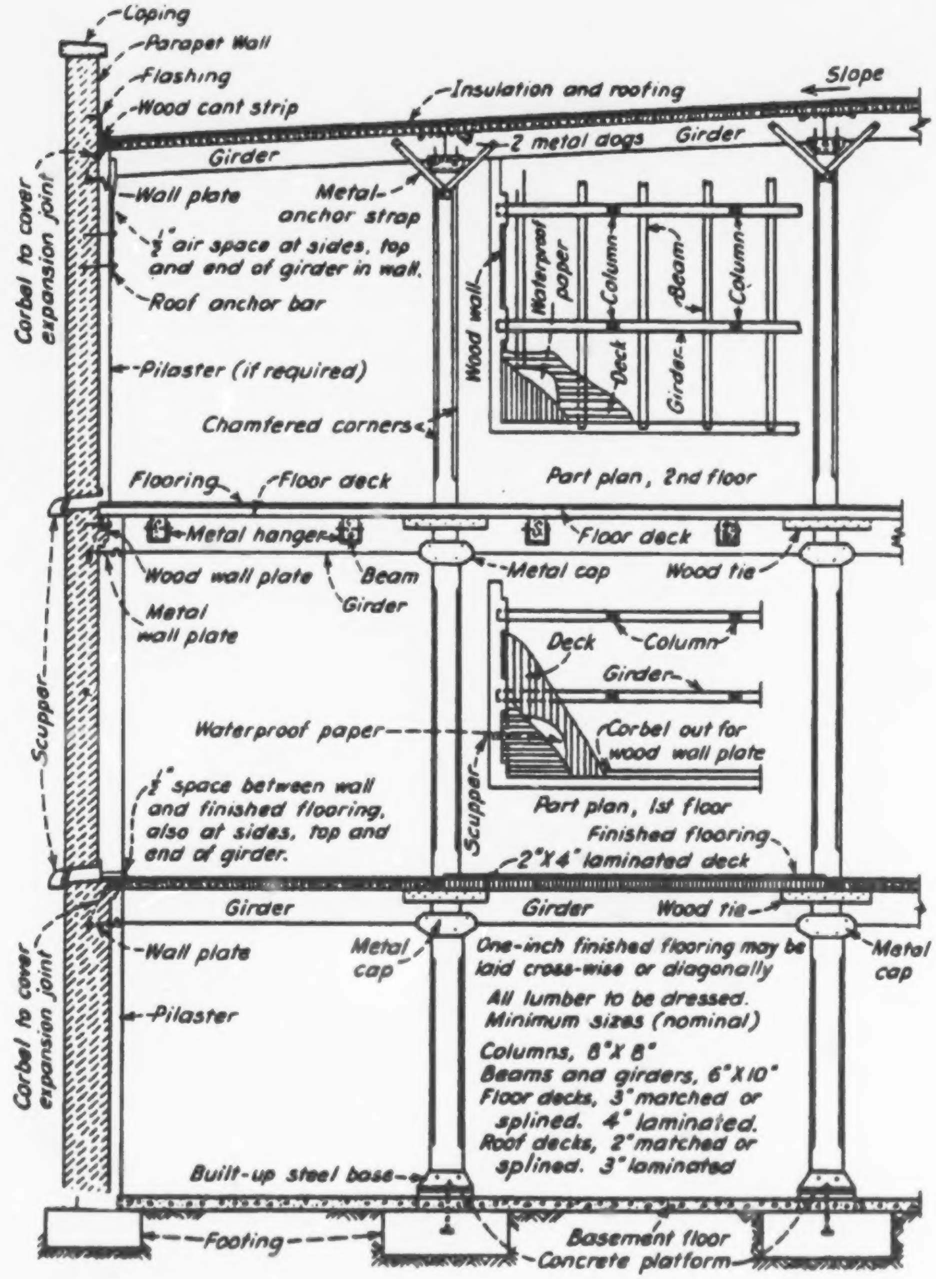

Column
Strap Reinforcement
Column
Reinforcement not shown
Column
Small Scale Plan

Reinforced Concrete Cantilever Footing on Piles


Reinforced Concrete Mat

Reinforced Concrete Mat Footing on Piles

Student Supplement 7—Heavy Timber Construction


Coping
Parapet Wall
Flashing
Wood cant strip
Insulation and roofing
Slope
Girder
2 metal dogs
Girder
Wall plate
Metal-anchor strap
½" air space at sides, top and end of girder in wall.
Roof anchor bar
Corbel to cover expansion joint
Pilaster (if required)
Chamfered corners
Wood wall
Waterproof paper
Column
Beam
Column
Deck
Girder
Part plan, 2nd floor
Flooring
Floor deck
Metal hanger
Floor deck
Wood wall plate
Beam
Metal cap
Wood tie
Metal wall plate
Girder
Deck
Column
Girder
Waterproof paper
Corbel out for wood wall plate
Scupper
½" space between wall and finished flooring, also at sides, top and end of girder.
Part plan, 1st floor
Finished flooring
2"X4" laminated deck
Girder
Girder
Wood tie
Wall plate
Metal cap
Metal cap
Corbel to cover expansion joint
Pilaster
Built-up steel base
Footing
Basement floor
Concrete platform

One-inch finished flooring may be laid cross-wise or diagonally

All lumber to be dressed.
Minimum sizes (nominal)
Columns, 8"X 8"
Beams and girders, 6"X10"
Floor decks, 3" matched or splined. 4" laminated.
Roof decks, 2" matched or splined. 3" laminated

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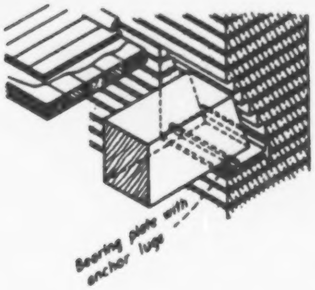
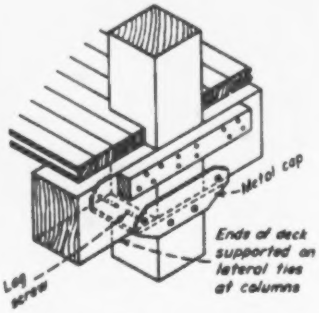
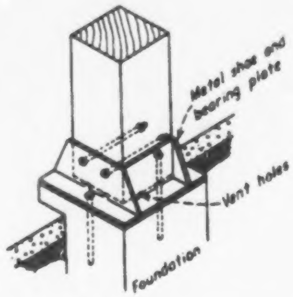
Heavy Timber Construction (continued)


Bearing plate with anchor lugs

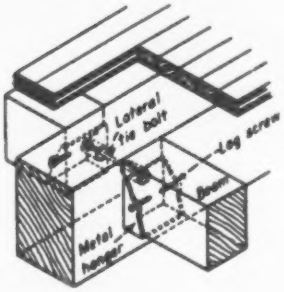
Girder Bearing on Metal Plate Wall


Metal cap
Ends of deck supported on lateral ties at columns
Lag screw

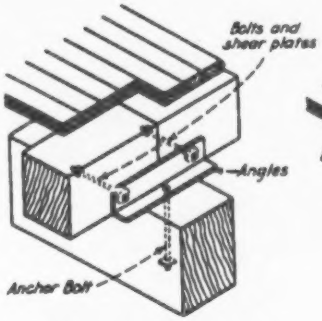
Metal Column Cap with Two Brackets


Metal shoe and bearing plate
Vent holes
Foundation

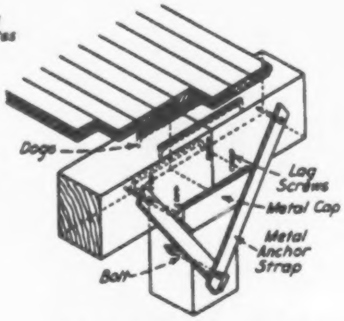
Built-Up Steel Column


Lateral tie bolt
Lag screw
Beam
Metal hanger

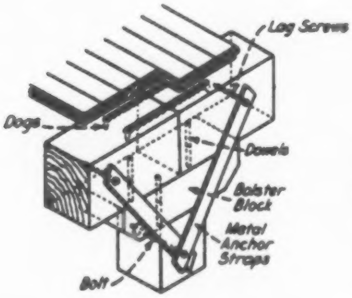
Metal Beam Hanger


Bolts and shear plates
Angles
Anchor Bolt

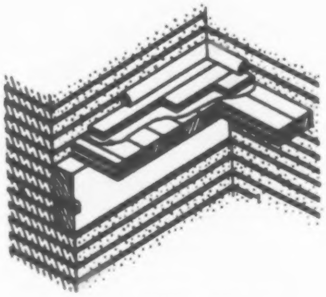
Beams Supported on Top of Girder


Dogs
Lag Screws
Metal Cap
Metal Anchor Strap
Bolt

Metal Column Cap Supporting Roof Girders


Lag Screws
Dogs
Dowels
Bolster Block
Metal Anchor Straps
Bolt

Wood Bolster Block Supporting Roof Girders



Wall Beam

Courtesy of the National Lumber Manufacturers' Association

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Objective 33

Assignment Sheet 1—Prepare Detail Drawings of Structural Steel Members

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy of measurement	______
• Correct detailing procedures used	______
• Drawing completed according to AISC *Manual of Steel Construction*	______
• Assignment is neat and legible	______

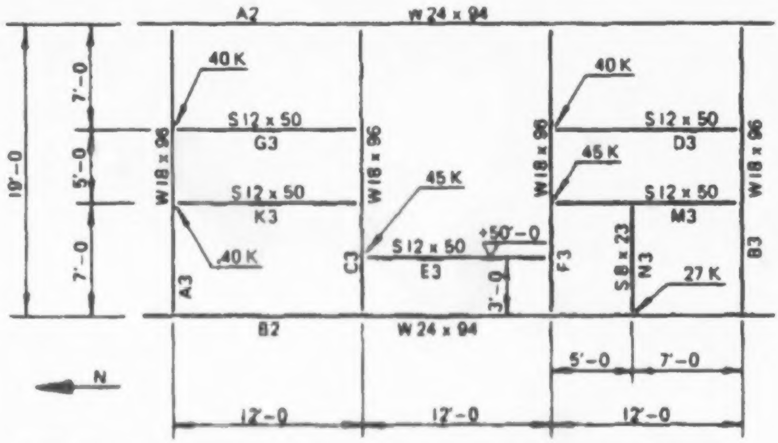
Basic Skills

Reading Mathematics Critical Thinking Technology (if CAD used)

Given

Floor plan

Figure 1


A2
W 24 x 94
40 K
40 K
7'-0
S 12 x 50
G3
S 12 x 50
D3
19'-0
5'-0
W18 x 96
W18 x 96
W18 x 96
W18 x 96
45 K
45 K
S 12 x 50
K3
S 12 x 50
M3
+50'-0
7'-0
40 K
C3
S 12 x 50
E3
F3
S8 x 23
N3
B3
27 K
A3
3'-0
B2
W 24 x 94
N
5'-0
7'-0
12'-0
12'-0
12'-0

ELEVATION: TOP OF STEEL TO BE (+50'—3) UNLESS OTHERWISE SHOWN
NOTES: ALL HOLES Ø .81 BOLTS Ø .75–A325

Directions

Use the AISC *Manual of Steel Construction* for reference.

1. Set up the final drawing on "B" or "C" size vellum. Drawing may be completed using a CAD system.

2. Use scale 3/8" = 1".

3. Prepare complete detail drawings of beams D3, E3, M3, N3, and C3 using framed beam connections. Refer to the student supplements as needed.

   a. Dimension to centerline of channel webs.

   b. Connection angles are welded to the beams. (Use 3/16" fillet weld.)

   c. Outstanding angles are bolted to the connecting beams.

4. Make sketches of beam connections. Scale 1" = 1'0".

039

Objective 34

Assignment Sheet 2—Draw to Scale a Concrete Engineering Drawing

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Accuracy of measurement	______
• Correct detailing procedures used	______
• Overall drawing presentation	______

Basic Skills

Reading Mathematics Critical Thinking Technology (if CAD used)

Given

Reduced set of plans for a culvert

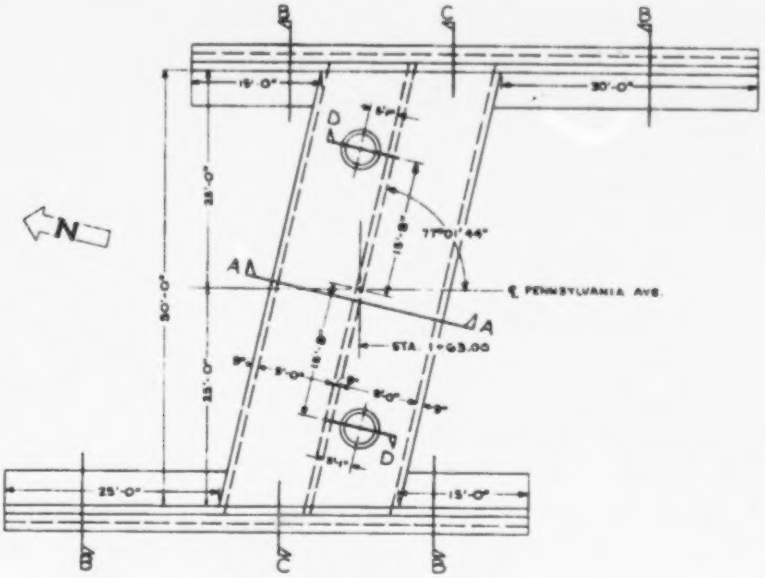
Directions

Complete the following steps:

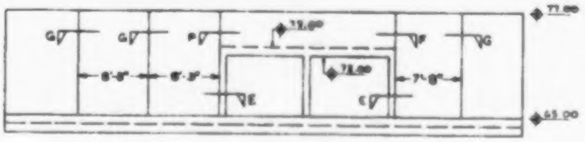
1. Redraw to scale.
2. Use "D" size format.
3. Use pencil on vellum or film lead on Mylar, or use CAD.
4. Draw the engineering drawing to the scales given on the reduced set of plans.
5. Letter general notes by hand or type on film or enter on computer and adhere to drawing.
6. Letter all dimensions.
7. Observe all standard procedures for drafting.

Assignment Sheet 2

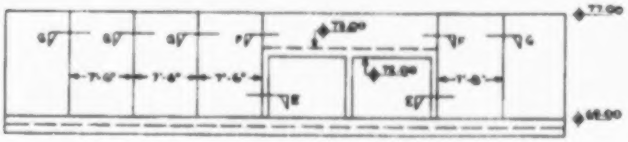
Figure 1


B
C
B
15'-0"
30'-0"
D
25'-0"
50'-0"
15'-0"
77°01'44"
N
A
A
℄ PENNSYLVANIA AVE.
STA. 1+63.00
5'-0"
D
25'-0"
15'-0"
B
C
B

PLAN VIEW OF CULVERT
1/8" = 1'-0"


77.00
G
G
F
F
G
E
E
63.00

WEST ELEVATION
1/8" = 1'-0"


77.00
G
G
G
F
F
G
E
E

EAST ELEVATION
1/8" = 1'-0"

General Notes

1. Concrete, 3000PSI-ASTM C94.
2. Reinforcing steel, 60,000 PSI, ASTM A615, Grade 60.
3. Unless otherwise noted, clear cover over all reinforcement shall be 2 in.
4. Chamfer all exposed edges 3/4 in.
5. All vertical and top of exposed concrete wall surfaces shall be cleaned and rubbed to conform to Sec. 2, Paragraph E(2) of the specifications. The earth side of concrete walls shall be rubbed from the top down a distance of 1 ft.
6. Minimum reinforcing steel lap splice shall be 36 bar diameters.

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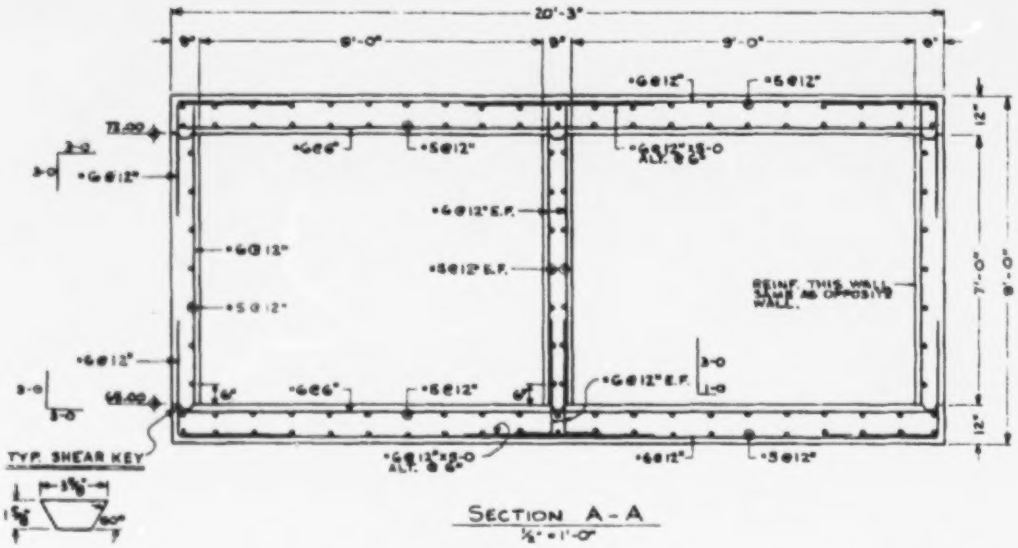
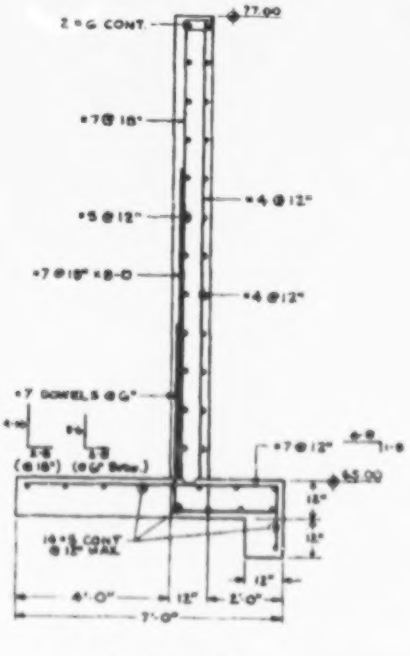
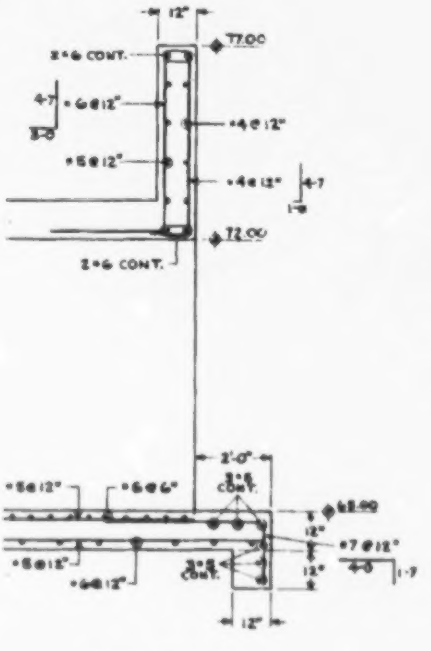
Figure 2


20'-3"
9"
9'-0"
9"
9'-0"
9"
#6@12"
#5@12"
72.00
#6@6"
#5@12"
#6@12"x15-0 ALT. @ 6"
3-0
2-0
#6@12"
#6@12" E.F.
#6@12"
#5@12" E.F.
#5@12"
REINF. THIS WALL SAME AS OPPOSITE WALL.
7'-0"
9'-0"
12"
#6@12"
3-0
1-0
#6@12" E.F.
65.00
#6@6"
#5@12"
6"
TYP. SHEAR KEY
3⅝"
1⅝"
60°
#6@12"x15-0 ALT. @ 6"
#6@12"
#5@12"
12"

SECTION A-A
½" = 1'-0"


2 #6 CONT.
77.00
#7@18"
#5@12"
#4@12"
#7@18" x8-0
#4@12"
#7 DOWELS @ 6"
4-0
3-8
(@18")
(@6" Btw.)
#7@12"
6-8
1-8
65.00
18"
12"
16 #5 CONT. @ 12" MAX.
12"
4'-0"
12"
2'-0"
7'-0"

SECTION B
¼" = 1'-0"


12"
2 #6 CONT.
77.00
4-7
3-0
#6@12"
#4@12"
#5@12"
#4@12"
4-7
1-0
72.00
2 #6 CONT.
2'-0"
3 #6 CONT.
#5@12"
#6@6"
65.00
12"
#7@12"
4-0
1-7
#5@12"
3 #6 CONT.
#6@12"
12"
12"

SECTION C
¼" = 1'-0"

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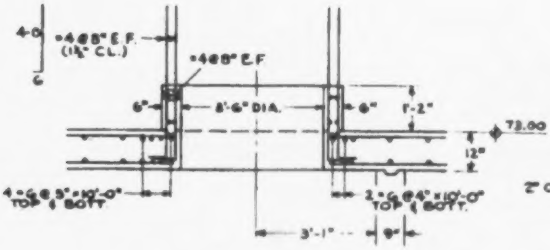
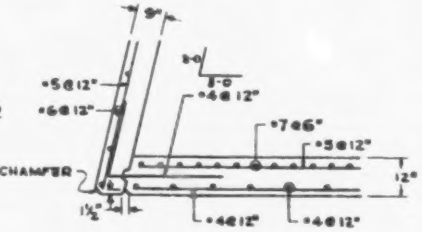
Assignment Sheet 2

Figure 3



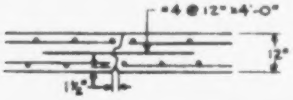
4-0
6
#4@8" E.F.
(1½" CL.)
#4@8" E.F
6"
8'-6" DIA.
6"
1'-2"
73.00
12"
4-#6@3"x10'-0" TOP & BOTT.
2-#6@4"x10'-0" TOP & BOTT.
3'-1"
9"

SECTION D
¼" = 1'-0"



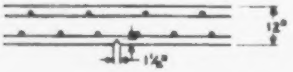
9"
3-0
3-0
#5@12"
#6@12"
#4@12"
#7@6"
#5@12"
2" CHAMFER
12"
1½"
#4@12"
#4@12"

SECTION E
½" = 1'-0"



#4@12"x4'-0"
12"
1½"

SECTION F
½" = 1'-0"



SECTION G
½" = 1'-0"

FLOOD CONTROL PROJECT I-5
RED BLUFF CA.

TWO BARREL CULVERT
HAYES STREET

B. JONES & ASSOCIATES
LOS ANGELES CA

DRAWN BY BTE
DATE 4-20-79
REV. DWG. HE-9

DRAWING HE-9

943

Objective 35

Assignment Sheet 3—Detail a Wood Truss

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Accuracy of measurement	______
• Correct detailing procedures used	______
• Overall drawing presentation	______

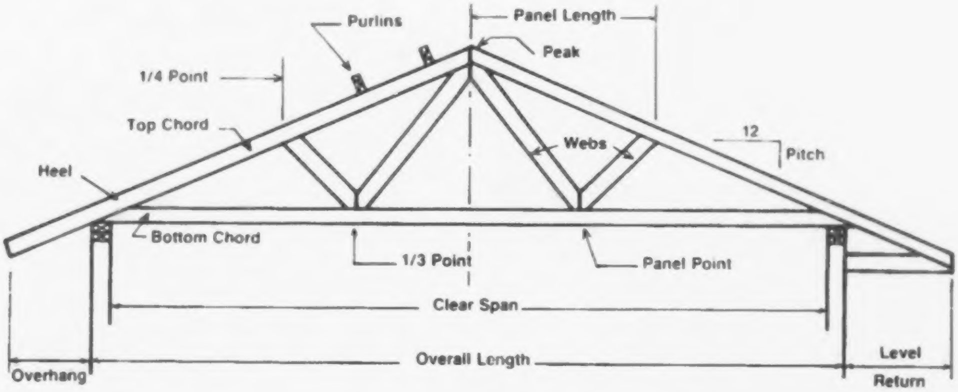
Basic Skills

Reading Mathematics Critical Thinking Technology (if CAD used)

Given

Examples of a common truss

Figure 1


Purlins
Panel Length
Peak
1/4 Point
Top Chord
Heel
Webs
12
Pitch
Bottom Chord
1/3 Point
Panel Point
Clear Span
Overhang
Overall Length
Level
Return

Assignment Sheet 3

Directions

Part A: Complete a detail drawing of a common wood truss. Use pencil on vellum or CAD and a scale of 1/4" = 1'0".

Common truss specifications:

Overall length—28'-0"	Pitch—4
Top chord—2 x 4	Sou pine #2 KD 15
Bottom chord—2 x 4	Sou pine #2 KD 15
Webs—2 x 4	Sou pine #3 KD 15
Truss plate	20 gage
Top chord live load	20.0 PSF
Top chord dead load	10.0 PSF
Bottom chord dead load	10.0 PSF
Total uniform load	40.0 PSF
Load adjustment	15%
Truss spacing	2.00 ft ctrs

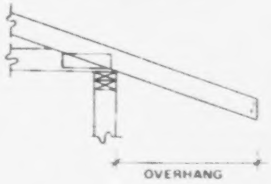
Overhang: Calculate the allowable overhang using the following chart.

Figure 2

MAXIMUM OVERHANG WITHOUT SUPPORT
TRUSS SPACING 2'0" CENTERS

LOAD PSF		20LL, 10DL		30LL, 10DL		40LL, 10DL	
LUMBER SIZE		2 × 4	2 × 6	2 × 4	2 × 6	2 × 4	2 × 6
SOUTHERN PINE KD							
#2	1.6E	4 - 1	6 - 0	3 - 6	5 - 2	3 - 2	4 - 8
#2 DEN	1.7E	4 - 1	6 - 7	3 - 7	5 - 8	3 - 3	5 - 1
#1	1.8E	4 - 2	6 - 8	3 - 8	5 - 9	3 - 4	5 - 2
DOUGLAS FIR MC19							
#2	1.7E	4 - 0	5 - 11	3 - 5	5 - 1	3 - 1	4 - 7
#1	1.8E	4 - 2	6 - 5	3 - 8	5 - 7	3 - 4	5 - 0

Plumb Cut Shown.
Square Cut Dotted.



Directions

Part B: Estimate the number of common wood trusses required for a structure that is rectangular, 28'0" wide by 56'0" in length, with two gable ends.

Answer: ____________________________

Instructions to calculate truss requirements:

Step 1. Determine the 24" on-center truss requirements by dividing the length of the building by 2.

Step 2. Add one truss to this total to provide a starting point.

Step 3. Determine the number of gable ends required and subtract from the total truss requirement.

Unit Contents

Student Components

Student Page

Objective Sheet 11-3

Information Sheet 11-5

Assignment Sheets

1—Develop Multiple Profiles to Determine Total Volume of Earthwork 11-11
2—Establish a Grade Plan and Determine Cut and Fill for a Cabin Site 11-15
3—Develop a Grading Plan for the MAVCC Topographic Survey Site 11-17

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify components of a site plan and determine cut and fill for a construction site. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to construction surveying with their definitions.
2. Define construction surveying.
3. List the four types of surveys used for a construction project.
4. Arrange in order the steps for placing a structure on a building site.
5. Select true statements about components of a site plan.
6. List the two components of a final plot plan.
7. List one key component of a preliminary construction survey.
8. Select true statements about the purpose of a grading plan.
9. List six elements of a grading plan.
10. Select true statements about the purpose of grade stakes.
11. Arrange in order the steps taken to establish a grade stake.
12. List four factors in referencing points for construction.
13. Arrange in order the steps taken to establish the required cut and fill for a building site.
14. Develop multiple profiles to determine total volume of earthwork. (Assignment Sheet 1)
15. Establish a grade plan and determine cut and fill for a cabin site. (Assignment Sheet 2)
16. Develop a grading plan for the MAVCC topographic survey site. (Assignment Sheet 3)

Information Sheet

Objective 1

Terms and definitions

a. **Construction drawings**—Plans that show size and position of structures that are to be erected, such as buildings, bridges, roads, parking lots, storage tanks, pipelines, etc.

b. **Contour grading**—A contour line used to show proposed finished contours that provide a visual plan view representation of how the finished site will look and how drainage will flow

c. **Easement**—An interest or right in land owned by another that entitles its holder to a specific limited use

d. **Grade stake**—A marker that is driven into the ground until its top is at the elevation desired for the finished elevation

e. **Hub (guineas)**—2″ x 2″ piece of wood of variable length with a tack driven into it to mark a precise position of a point

f. **Invert elevations**—Low points on the inside circumference of the pipe

g. **Keel (blue tops)**—A blue lumber crayon used to mark stakes that are at grade; commonly used for grading operations along the edges of highways and railroads

h. **Stake**—1″x2″x18″ or longer piece of wood sharpened at one end that is driven into the ground to mark a position; may be flagged

Objective 2

Definition of construction surveying—Transference of the dimensions on a drawing to the ground so the construction work is done in its correct position; this is sometimes called setting line and grades

Note: The work of the surveyor for construction projects is called layout work.

Objective 3

Types of surveys used for a construction project

a. Property or boundary survey—Used to establish the location and dimensions of the property

b. Topographic survey—Used to establish existing conditions of the property such as contours, man-made and natural features

c. Construction survey—Used to determine the position and elevation of the features of the construction work

d. As-built survey—Used to determine the position of finished structures, serves as a check of the contractor's work and shows location of components that will need future maintenance (water lines, sewer, power lines, etc.)

Information Sheet

Objective 4

Steps for placing a structure on a building site

a. Contractor for construction job is given a property survey by owner.

b. Plans are developed by an architect using a site map. This drawing is called a building plot plan.

c. A preliminary survey (construction survey) is completed.

d. Determine minimum setback distances from edge of lot to front edge of structure.

e. Determine any easements before placement of building corners.

f. Establish the correct building dimensions.

g. Develop a grading plan.

h. Determine building site cut and fill (earthwork calculations).

i. Structure will be placed at the desired elevations.

Objective 5

Components of a site plan

a. Drawn at large scale: 1″ = 10′ or 1″ = 20′

b. Includes property boundaries

c. Elevations for preparation of contour lines

d. Location of existing structures on the site or adjacent to it

e. Location of existing streets, sidewalks, curbs, and fire hydrants

f. Positions of any immovable objects

g. Location of gas and water lines, storm and sanitary sewers, manhole locations, invert elevations, power lines, telephone lines, light poles, trees, etc.

Objective 6

Components of a final plot plan

a. Location of the building in respect to property lines, streets, and utilities

b. Final contour lines as they will exist after construction is complete

Objective 7

Components of a preliminary construction survey

Note: These surveys are generally completed before construction begins.

a. Shows existing site conditions

b. Includes measurements of horizontal and vertical positions of the foundation of the structure

Objective 8

Purpose of a grading plan

a. This plan is used by the engineer to design a firm foundation for the structure and designate appropriate drainage for the site.

b. Grading plans provide elevations at appropriate locations with 2" x 2" wooden hubs and wooden stakes.

c. The stakes identify the elevation and the amount of cut or fill required above or below the top of the hub.

d. The backs of the stakes give information on the horizontal location to reference points.

Note: The construction crew will use these hubs and stake readings to tell the equipment operator where to cut or fill in earth.

Objective 9

Elements of a grading plan

a. Are independent of other site plans

b. Plan's base map is a topographic map and drawn to scale

c. Includes the following:

- Property boundary
- Lot and easement lines
- Sections for the pad and streets
- Setbacks and structures
- Cross section for ditches, dikes, and drainage structures

d. Areas of fill are shaded to be different from cut areas

e. Notes

- Name of soil engineer
- Project engineer
- Jurisdictional agency
- Special instructions

f. Includes tables of cut and fill quantities

Information Sheet

Objective 10

Purpose of grade stakes

a. Used to establish elevations that guide the contractor so that the project is constructed to the required elevations

b. Placed after rough grading is completed to establish and control the final earthwork

c. Needed for sewer, street pavements, railroads, buildings, etc.

d. Used to mark required cut and fill (usually given in whole numbers of feet)

e. Are set at points that have the same ground and grade elevation

Note: A line connecting grade stakes defines the change from cut to fill.

Objective 11

Steps taken to establish a grade stake

Note: Refer to Unit 6, "Interpretation of Surveyor's Notations," pages 6–34 and 6–35.

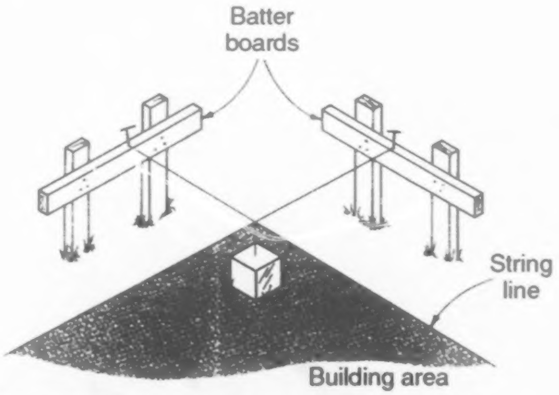
a. The surveyor determines the required elevation of a point and subtracts it from the H.I.

b. The above step establishes the rod reading when the top of the stake is at the desired elevation.

c. The stake is then driven into the ground until the required rod reading is obtained.

d. A set of batter boards and reference stakes are erected near each corner. Nails are driven into the batter boards so that string can be stretched tightly between them to define the outside wall or form line of the building.

Figure 1



ELEMENTARY SURVEYING 9/E by Wolf/Brinker, ©1998.
Reprinted by permission of Prentice-Hall, Inc., Upper Saddle River, NJ.

Objective 12

Factors in referencing points for construction

a. Due to the vulnerability of survey stakes during construction it is necessary to reference to other points (reference points) so a stake can be reestablished if displaced.

b. A reference point should be fairly permanent.

c. A reference point marker could be any of the following:

- Crosses or marks chiseled into concrete pavement or curbs or sidewalks
- Nails or bottle caps driven into bituminous pavements or trees
- Corners of existing buildings

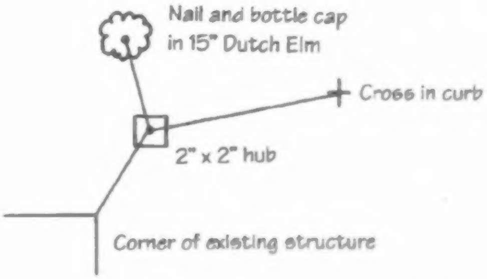
d. Important reference points should be recorded and described in notes in case markings for location at site are obliterated.

e. Reference points are kept to less than 6 feet so points can easily be reestablished with a carpenter's rule and plumb bob.

f. Guard stakes and flags are used to protect a reference point from being disturbed.

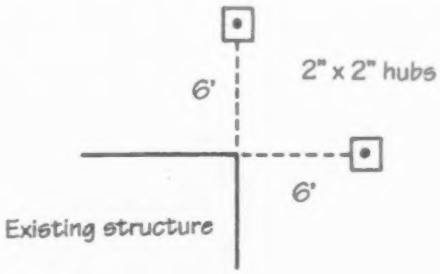
g. A common method of referencing is using three points.

Figure 2


Nail and bottle cap in 15" Dutch Elm
Cross in curb
2" x 2" hub
Corner of existing structure

h. It is preferred to have reference points set the same distance away from the survey point.

Figure 3



Information Sheet

Objective 13

Steps in establishing the required cut and fill for a building site

a. First, plot original contours of the site on a plan view.

b. Determine where the new contours will be and if the building is going to be level or on a slope.

c. Original contours that are required to change are shown as dashed. Original contours that will remain unchanged are shown as solid thin lines.

d. A cutting line is drawn through the building in the plan view.

e. Next, construction lines are drawn perpendicular from the cutting line from both the original contours and the new proposed contours to a profile grid.

Note: Vertical scale (1″ = 1′0″) is exaggerated from the horizontal scale (1″ = 10′).

f. The areas that will require cut or fill work are the areas of discrepancy shown shaded in the profile grid.

- If a new contour line shows higher in elevation on the profile grid, it requires the area to be filled.
- If a new contour line is lower in elevation than the old contour line, the area needs to be cut.

g. At this point mathematical calculations can be utilized to determine the area and volume of earth to be moved.

Note: See Unit 7, "Topographic Mapping," Student Supplements 2 and 3, for different methods for determining cut and fill area and volume.

h. Cutting lines through the building site five to ten feet apart and calculating the areas to be cut or filled will determine the total volume of earth to be moved.

Objective 14

Assignment Sheet 1—Develop Multiple Profiles to Determine Total Volume of Earthwork

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Accuracy of plotting	______
• Mathematical calculations for earthwork	______
• Assignment is neat and legible	______

Basic Skills

Reading Mathematics Critical Thinking

Directions

Given: A graded site plan showing three section cuts through the housing site.

Step 1: Set up a profile grid for each section cut (A–A′, B–B′, C–C′) or use separate colors for each profile to distinguish between the three.

Note: Section A–A′ is already completed for you.

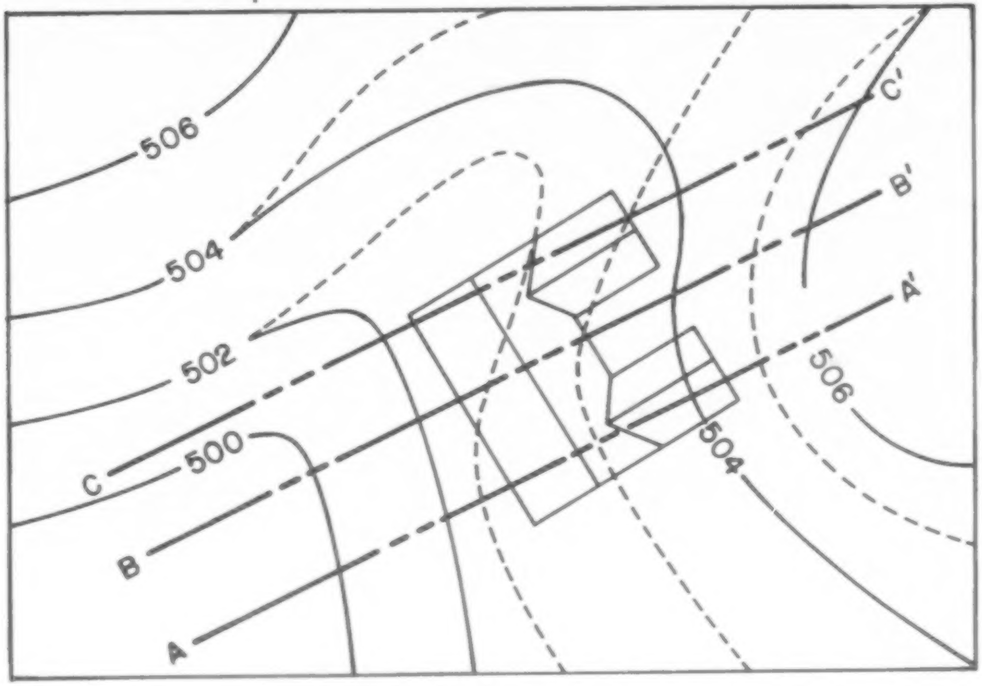
Step 2: Construct a profile for section cut, showing both the original contours and the proposed contours. Indicate proposed contours with a dashed line.

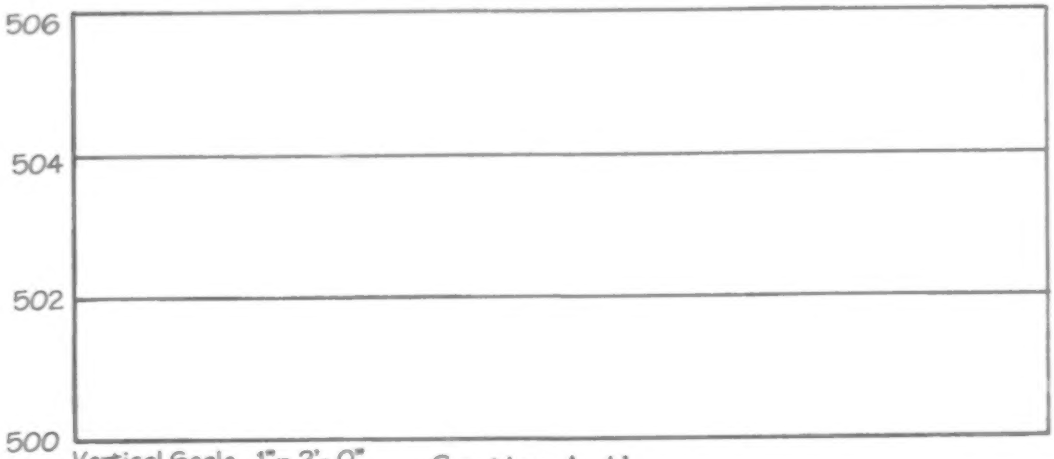
Step 3: Determine areas for cut and fill by labeling each appropriately.

Assignment Sheet 1

Graded site plan

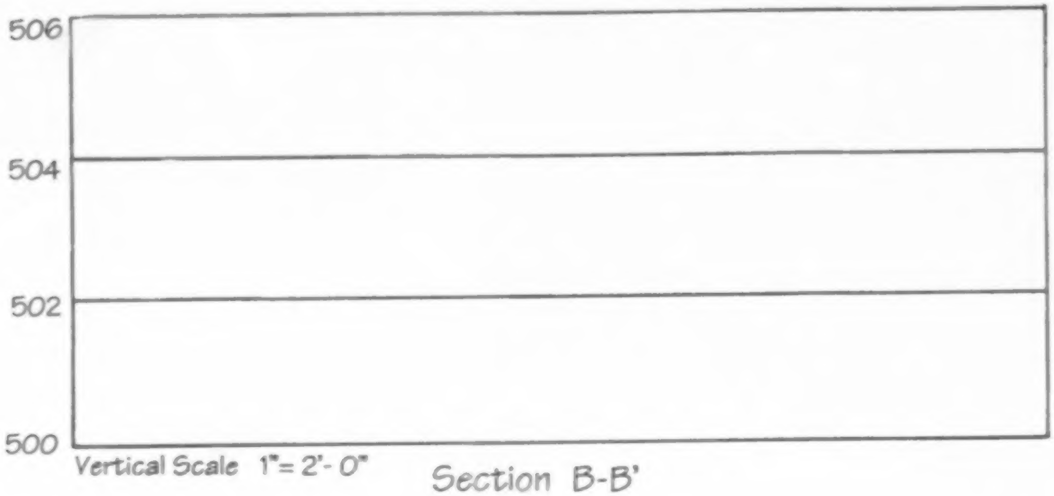
Horizontal Scale 1"= 30'


506
504
502
500
504
506
A
A'
B
B'
C
C'


506
504
502
500

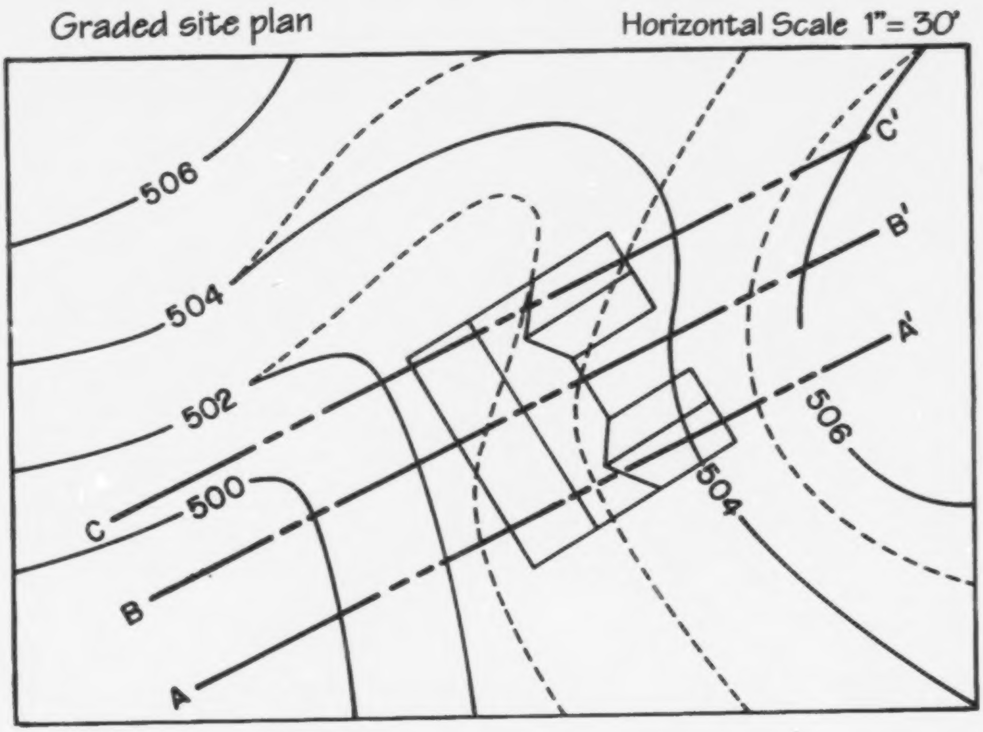
Vertical Scale 1"= 2'- 0"

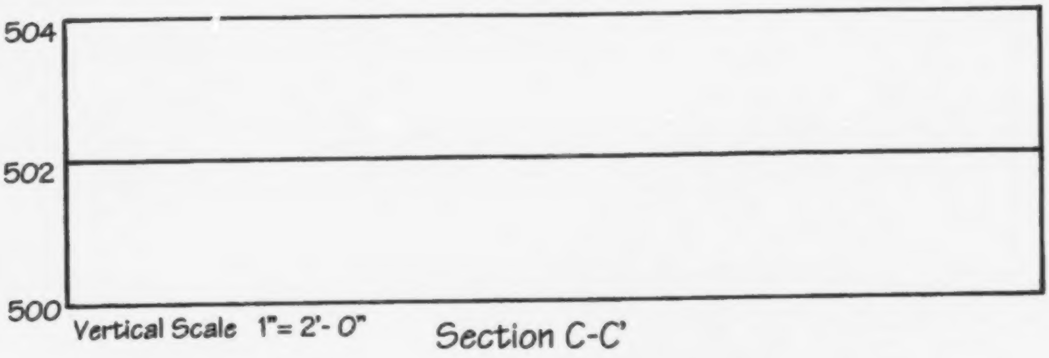
Section A-A'


506
504
502
500
Vertical Scale 1"= 2'- 0"

Section B-B'

Assignment Sheet 1


Graded site plan
Horizontal Scale 1"= 30'
506
504
502
500
C
C'
B
B'
A
A'
506
504


504
502
500
Vertical Scale 1"= 2'- 0"
Section C-C'

Objective 15

Assignment Sheet 2—Establish a Grade Plan and Determine Cut and Fill for a Cabin Site

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	**Rating**
• Accuracy of plotting	_____
• Mathematical calculations for earthwork	_____
• Assignment is neat and legible	_____

Basic Skills

Reading Mathematics Critical Thinking

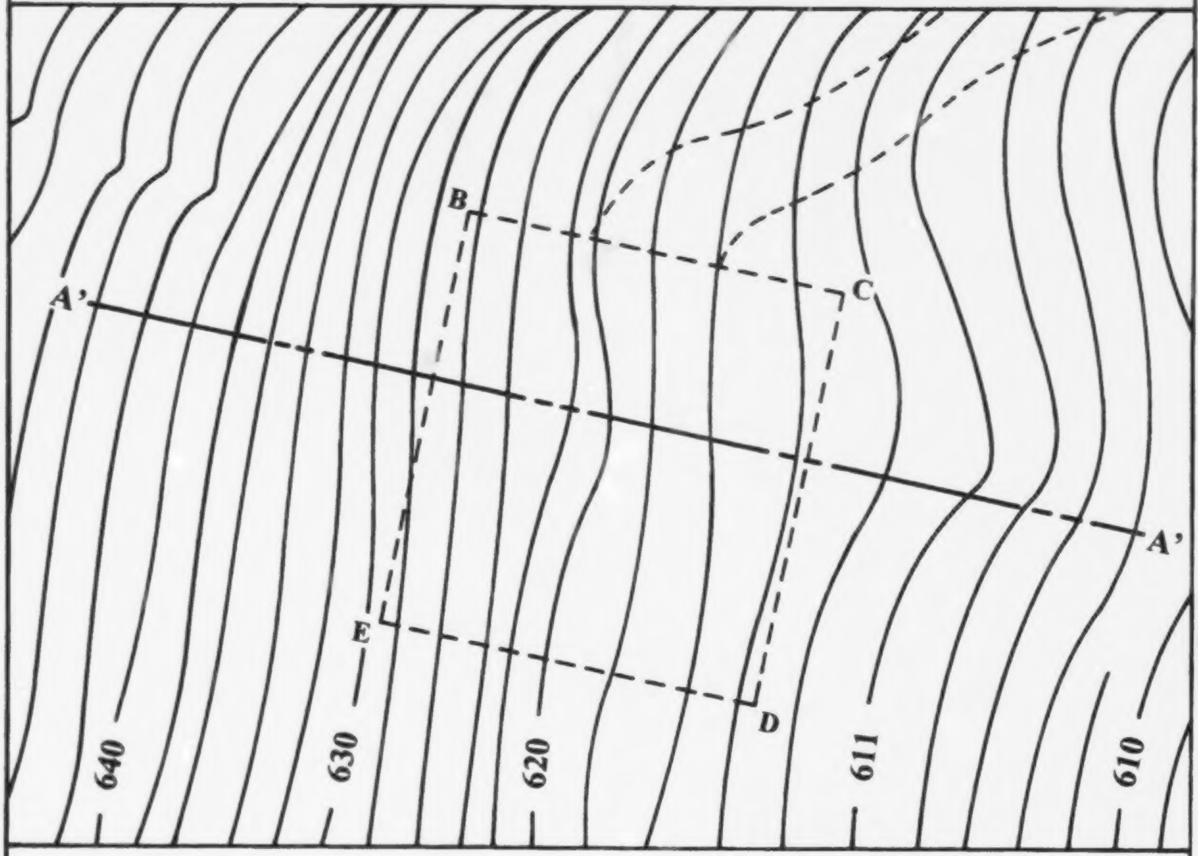
Given: A mountain cabin site

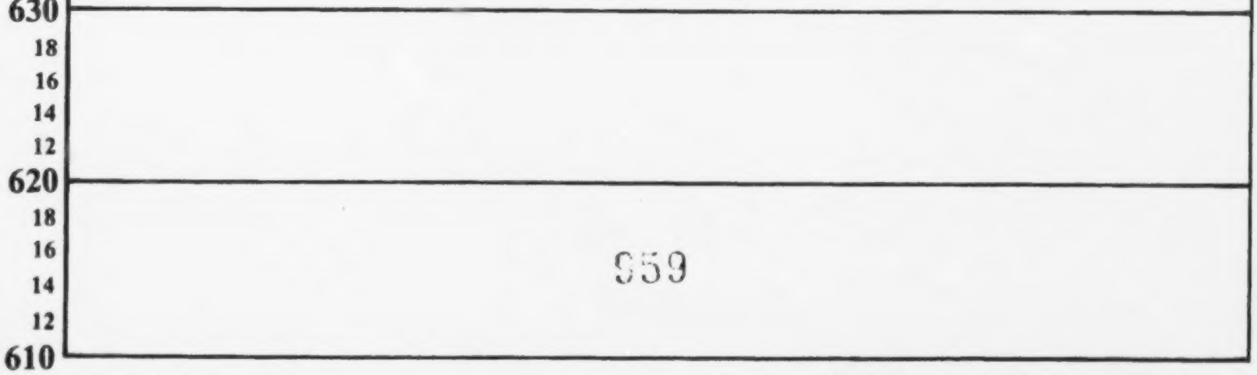
Horizontal scale: 1″ = 20′
Vertical scale: 1″ = 10′
Contour interval: 2 ft.

Directions

A mountain cabin site (B, C, D, E) needs to be leveled to elevation 6120 ft. prior to construction of a foundation. Construct a profile view of existing conditions with a vertical scale of 1″—10′. Determine the necessary changes to the grade to level the cabin site to 6120′. Plot the new contour lines and develop a second profile. Determine cut and fill.

Mountain Cabin Site Worksheet


B
C
A'
A'
E
D
640
630
620
611
610



Objective 16

Assignment Sheet 3—Develop a Grading Plan for the MAVCC Topographic Survey Site

Name ______________________________ Overall Rating __________

Date ______________________________

Evaluation Criteria	Rating
• Accuracy of plotting	______
• Mathematical calculations for earthwork	______
• Proper use of CAD software	______

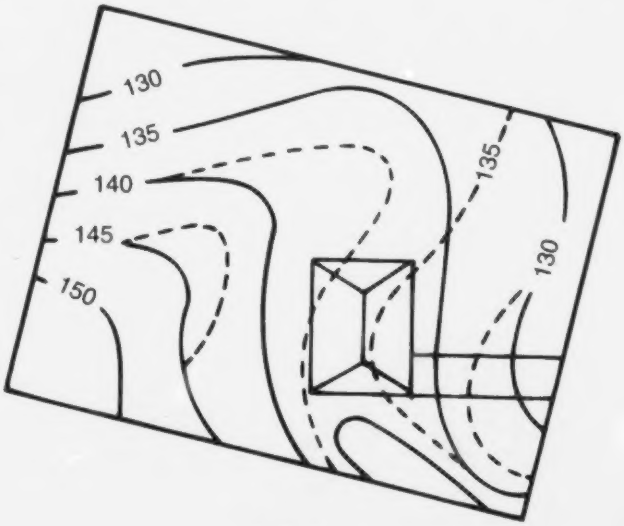
Basic Skills

Reading Mathematics Critical Thinking Technology

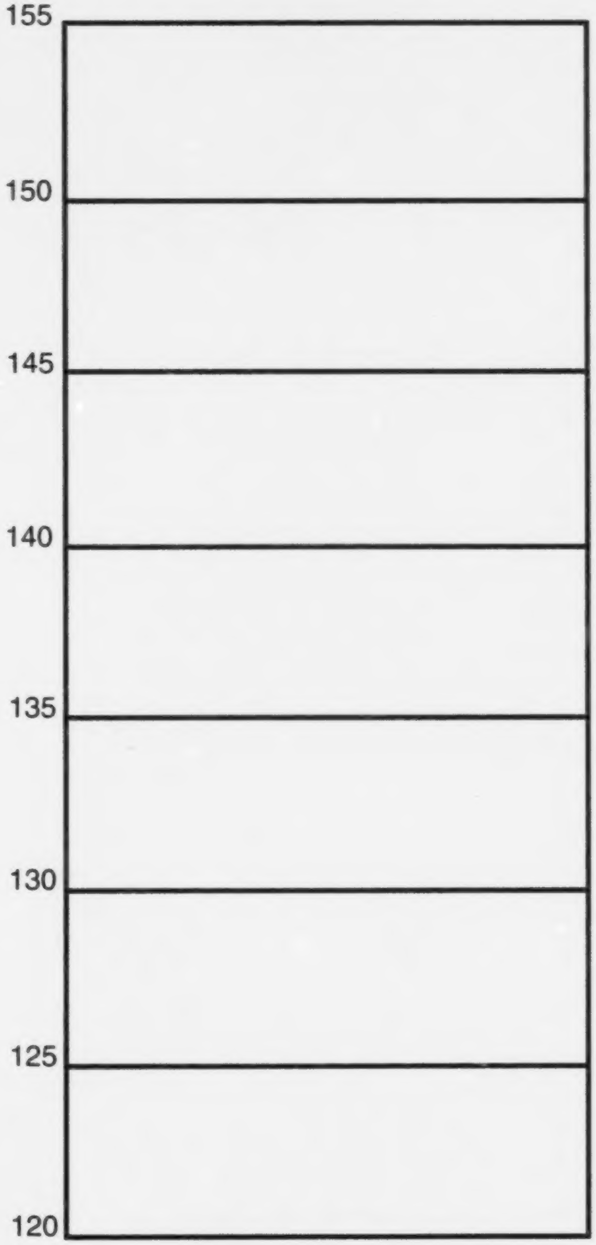
Directions

This assignment will require a civil CAD software program. You will use the contour map developed in Unit 7, "Topographic Mapping," Assignment Sheet 4, to complete this assignment.

1. Use the area around the proposed structure to develop your grading plan. Propose new contour lines where the structure will be constructed.
2. Following the instructions given in this unit for establishing profiles to develop a cut and fill requirement and your CAD software instructions for generating profiles, construct three to five profile cuts across the site.
3. Determine cut and fill for each profile.
4. Calculate total volume of cut and fill.
5. Plot out map.



Elevation in Feet
Vertical Scale 1" = 5'0"


155
150
145
140
135
130
125
120

Procedures for the Preparation of Maps and Plans

Unit Contents

Student Components

Student Page

Objective Sheet 12-3

Information Sheet 12-5

Assignment Sheets

1—Complete a Tracing in Ink of a Mapped Area 12-21
2—Prepare a Final Presentation of the MAVCC Topographic Survey Map 12-23

Job Sheet

1—Use a Polar Planimeter to Determine Acreage 12-25

Unit 12

Procedures for the Preparation of Maps and Plans

Objective Sheet

Unit Objective

After completing this unit, the student should be able to identify components of a map or plan and prepare a final presentation of the MAVCC topographic survey map. The student should demonstrate these competencies by completing the assignment sheets and job sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to preparation of maps and plans with their definitions.
2. Match types of drafting media with their characteristics.
3. List methods of drawing reproduction.
4. Distinguish between maps and plans.
5. Label components of a map layout.
6. State the purpose of a legend.
7. Complete statements about north (meridian) arrows.
8. List two facts about scales and scale bars.
9. List the components of a title block.
10. Arrange in order the steps for drafting a map or plan.
11. List the standard sheet formats for a set of civil drawings.
12. List the two methods of map registration.
13. Complete statements about lettering considerations.
14. Match useful tools for the creation and production of maps and plans with their descriptions.
15. Distinguish among the three types of planimeters.
16. Label the parts of a polar planimeter.
17. Complete statements related to the applications of aerial photography.
18. Distinguish between advantages and disadvantages of using aerial photography.
19. Select true statements concerning aerial photo control.

Objective Sheet

20. Complete statements concerning general facts about aerial photogrammetry.

21. Arrange in order the steps for using a stereoscope.

22. List common mistakes made in map drafting.

23. Complete a tracing in ink of a mapped area. (Assignment Sheet 1)

24. Prepare a final presentation of the MAVCC topographic survey map. (Assignment Sheet 2)

25. Use a polar planimeter to determine acreage. (Job Sheet 1)

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Information Sheet

Objective 1

Terms and definitions

a. **Acetate**—A clear plastic film which has no drafting surface

b. **Gloss**—A surface that has a bright, polished finish

c. **Matte**—A slightly rough finish free from shine or highlights

d. **Medium (pl. Media)**—A material used to carry information; in drafting, includes various papers and films used for written and drafted information

e. **Mylar**—Brand name of a polyester film used as a base for drawing in the drafting industry

f. **Opaque**—Not permitting the passage of light

g. **Polyester film**—A drawing medium that is matte on one or both sides for a drafting surface; accepts both ink and pencil and comes in various mil thicknesses

h. **Reproducible**—An original drawing on a translucent material suitable for diazo reproduction

i. **Sensitized material**—A diazo product used in the reproduction process of maps and topos; either negative or positive images can be placed on this film with more drafting added later as needed

j. **Translucent**—Admitting and diffusing light so that objects beyond cannot be clearly distinguished; partly transparent

k. **Transparent**—Transmitting light without appreciable scattering so that bodies lying beyond are clearly visible

l. **Vellum**—A prepared tracing paper that has the quality of strength and transparency to make a good drawing surface; generally used with pencil and ink

Objective 2

Types of drafting media and their characteristics

Note: The media listed below can be obtained from different vendors in roll stock or pre-cut sheets, plain or printed.

a. Prepared tracing paper (vellum)—100% rag translucent paper which accepts pencil and ink

b. Natural tracing paper (films/bumwad/yellow trace)—Used for quick notes or changes over a drawing

c. Tracing and drawing polyester films—May be sensitized for special diazo reproduction process or unsensitized for standard work
    - Are available with single or double matte surfaces which accept ink, pencil, or plastic film lead
    - Are available in different mil thicknesses (.002" to .007')
    - High translucent film is used for overlay drafting.
    - Clear uncoated polyester film is used for overlay work or protective covers. It accepts tape, but does not accept ink.

d. Gridded media—Film or paper printed with black or blue 90° grids with single or double matte surfaces

Objective 3

Methods of drawing reproduction

a. Diazo print—Blueline or blackline paper or film prints

b. Intermediate (sepia or black)—Film or paper copy that becomes a second original of the copied drawing

c. Xerographic copying (Xeroxing)

d. Photo engraving

e. Photo offset printing

f. Computer plot

Objective 4

Difference between a map and plan

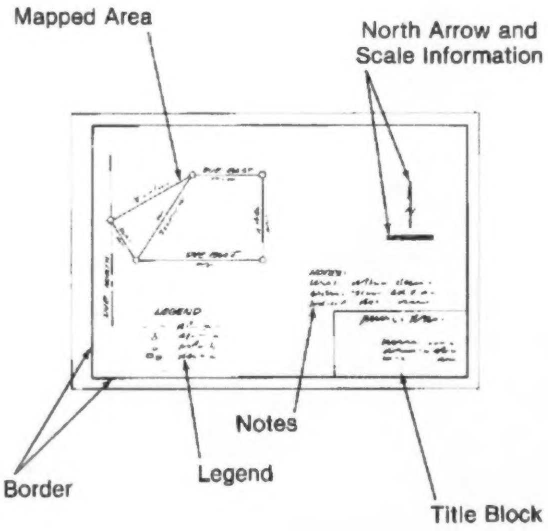
a. Plans are the documents that illustrate what the finished project will look like.

b. The finished document will be submitted as a map.

Objective 5

Components of a map or plan layout

Figure 1

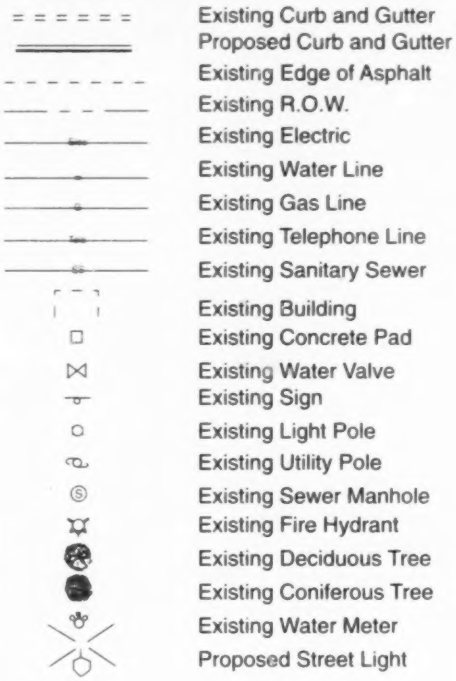


Objective 6

Purpose of a legend—Used to represent the different types of symbols found on a map; map symbols are used when a feature shows up more than once on a map

Note: If a feature shows up only once on a map, it is labeled on the map body itself.

Figure 2


Existing Curb and Gutter
Proposed Curb and Gutter
Existing Edge of Asphalt
Existing R.O.W.
Existing Electric
Existing Water Line
Existing Gas Line
Existing Telephone Line
Existing Sanitary Sewer
Existing Building
Existing Concrete Pad
Existing Water Valve
Existing Sign
Existing Light Pole
Existing Utility Pole
Existing Sewer Manhole
Existing Fire Hydrant
Existing Deciduous Tree
Existing Coniferous Tree
Existing Water Meter
Proposed Street Light

Objective 7

North (meridian) arrow

a. Arrow is placed with north generally oriented at the top of the map sheet.

Note: This is not always possible.

b. There are many styles of north arrows.

Note: Refer to Unit 4: Standard Symbols and Abbreviations

c. True, grid and magnetic north may all be shown on a map.

Objective 8

Scale and scale bar

a. Each plan will have the vertical and horizontal scale documented.

b. Written scale and scale bar are generally shown together.

Objective 9

Components of a title block

a. Type of map

b. Name of property or project

c. Owner or user

d. Location or area

e. Date completed

f. Scale

g. Contour interval

h. Horizontal and vertical datums

i. Name of surveyor, engineer, or architect and license number where applicable

Note: Additional data may be required on special purpose maps.

Objective 10

Steps for drafting a map or plan

a. Select sheet medium (film or paper) and size.

b. Lay in the border.

- Use heavy ink lines.
- Leave a larger border at left of sheet to allow for possible future binding.

c. Plot in map area.

- Determine necessary space for the layout of the map area.
- Place map area generally to the left of center for the sheet leaving ample room around the mapped area for notes and dimensions.
- Lay in additional features.

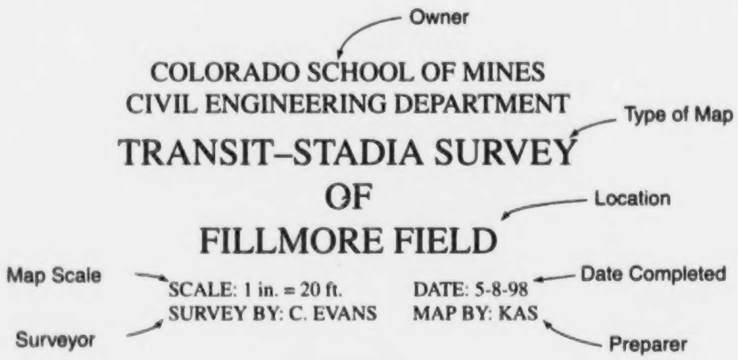
  Examples: Cultural and vegetation symbols
- Lay in the location of labels and dimensions.

d. Place the title block

- Place title block in the lower right hand corner or along bottom of plan sheet.

  Note: Never place it within the map area.

  Figure 3



COLORADO SCHOOL OF MINES
CIVIL ENGINEERING DEPARTMENT
TRANSIT–STADIA SURVEY
OF
FILLMORE FIELD
SCALE: 1 in. = 20 ft. DATE: 5-8-98
SURVEY BY: C. EVANS MAP BY: KAS

- It is common to lay out a title block around a centerline.
- Size of lettering adjusts proportionally with the importance of the information in the title block.

e. Locate the (meridian) north arrow.

- Generally located to the top and right of sheet
- Generally shown with the scale and scale bar

f. Place the legend.

- Locate it where it best balances the sheet.

  Note: If several map areas of items are included on the sheet, locate the legend near the items the legend applies to.

- List symbols in one column with feature names in the column next to it.
- Place the label "legend" centrally over the columns and use a larger letter size.

g. Letter in the notes.

- Cover special features pertaining to the individual map.
- Locate in a prominent place, generally to the left or above the title block.
- These may be hand lettered, mechanical lettered (Leroy), or typed on polyester adhesive-backed material.

h. Set up for final plot.

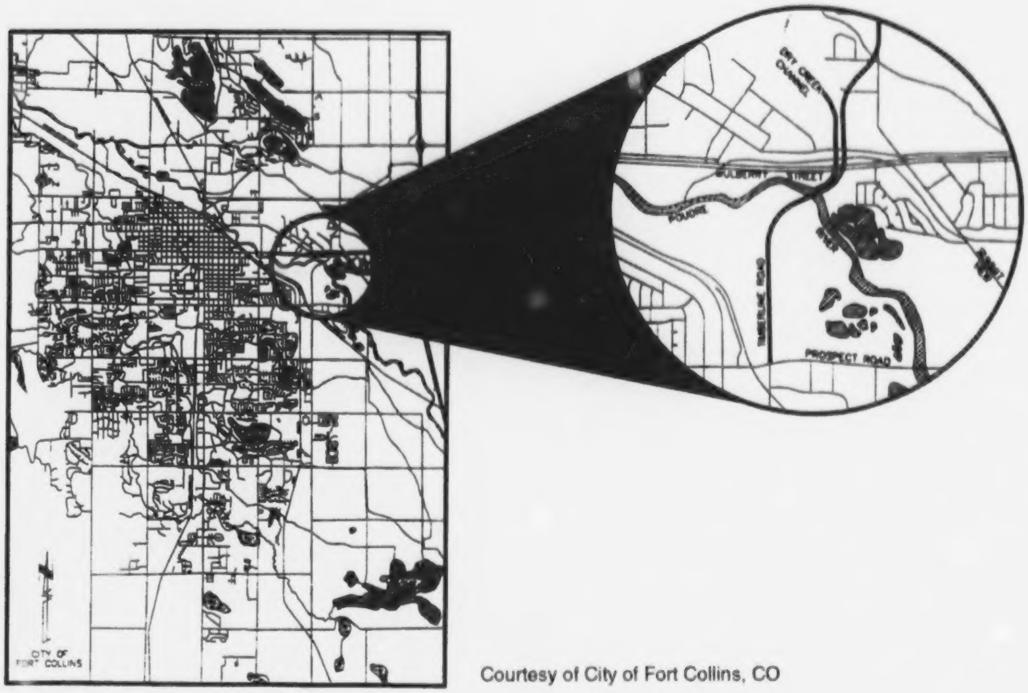
Objective 11

Standard sheet format for a set of civil drawings

a. Cover sheet

- Project title and number
- Vicinity map

Figure 4


DRY CREEK CHANNEL
MULBERRY STREET
POUDRE
TIMBERLINE ROAD
PROSPECT ROAD
CITY OF FORT COLLINS

Courtesy of City of Fort Collins, CO

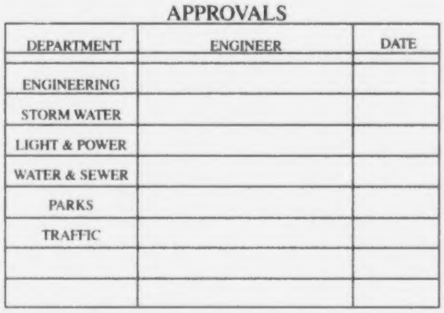
- Sheet index or table of contents

Figure 5

SHEET NO.	SHEET INDEX	DESCRIPTION
1	–	Cover Sheet
2	–	General Notes
3	–	Typical Cross Sections
4-13	R1-R10	Timberline Road Plan and Profile
14	R11	Countryside Drive Plan and Profile
15	R12	Lincoln Avenue Plan and Profile
16	R13	Donella Court Plan and Profile
17-22	S1-S6	Bridge Structures
23-25	D1-D3	Dry Creek Plan and Profile
26-27	A1-A2	Alternate Channel Plan and Profile
28	C1	Conveyance Channel Plan and Profile
29	SI1	Siphon Plan and Profile
30	L1	Levee Plan and Profile
31-34	B1-B4	Bike Trail Plan and Profile
35	RW1	Runway Extension

- Approval block

Figure 6



APPROVALS

DEPARTMENT	ENGINEER	DATE
ENGINEERING		
STORM WATER		
LIGHT & POWER		
WATER & SEWER		
PARKS		
TRAFFIC		

b. General notes and design data

- General notes include information directed at the contractor relevant to the project.
- Design data include information on where and how the project connects to existing survey data locations.

c. Quantity sheets—Needed for bids for earthwork

d. Key map—Relates station locations to sheet numbers

e. Removal and demolition plan

- Shows utility relocation and location of existing utilities
- Shows removal of trees and structures

f. Plan and profiles

- Construction notes
- Level of detail important on these plans

g. Cross sections

h. Detail sheets

i. Miscellaneous plans, depending on type of project

- Grading plans
- Landscape plans
- Traffic control plans
- Storm drainage plans
- Erosion control plans

Objective 12

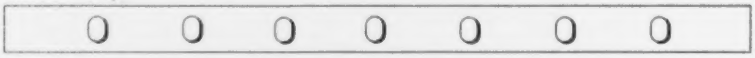
Methods of map registration

Note: With layer capabilities of the CAD software programs, this is less of an issue for map construction. Due to the many map archives, this is important to know.

a. Pin registration

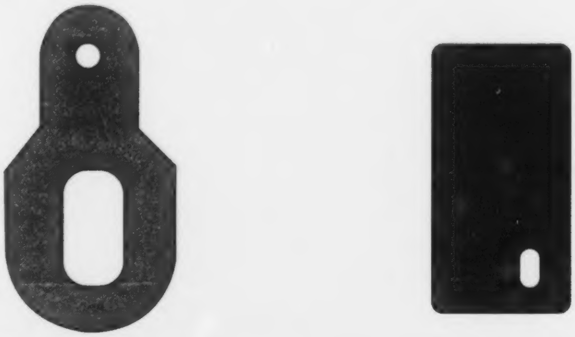
- Pin bar—Uses a metal strip with projecting pins and stable polyester film properly punched on one edge at corresponding spaces to provide precise registration

  Figure 7



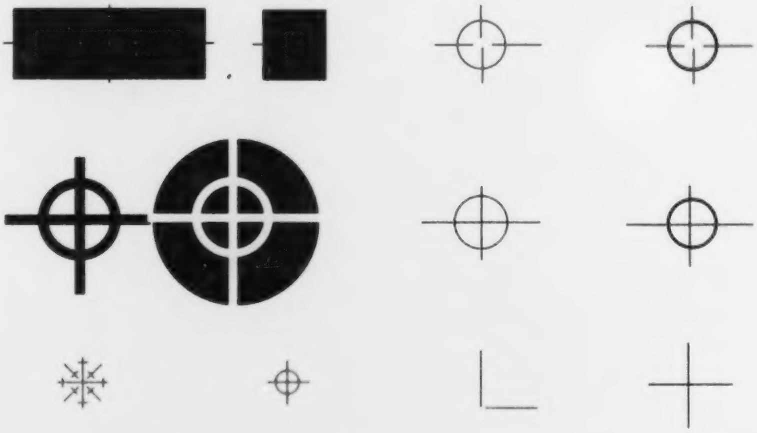
- Individual pins—Uses separate pins that snap into attached tabs that provide registration to multiple sheets for overlay drafting

  Figure 8



b. Register marks—Decals or hand-drawn targets that line up on a base sheet with corresponding marks on the overlay

Figure 9



Objective 13

Lettering considerations for maps and plans

Note: Much of the information on a map is shown by lettering. Careful consideration of size, style, and placement makes a map easier to read.

a. Lettering usually varies in size on maps in direct relation to the importance of the item to be lettered.

b. Lettering size should be chosen with the reduction factor for final reproduction considered.

c. Lettering should be placed so it is readable from the bottom and the right hand side of the drawing.

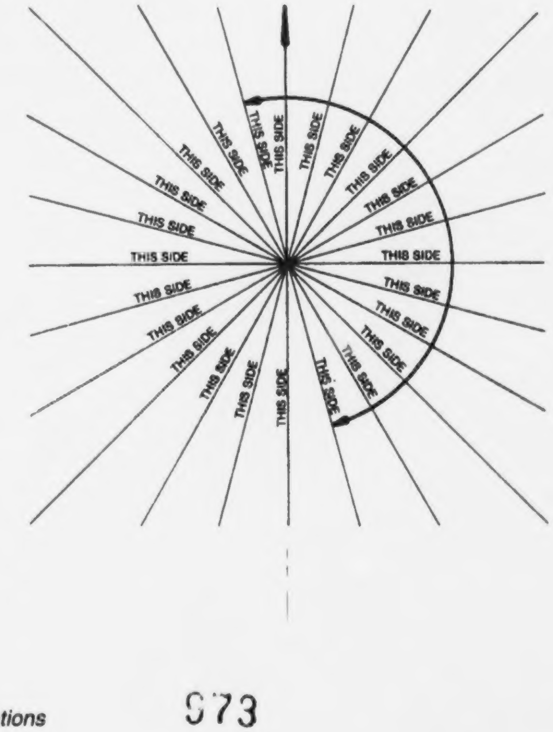
d. Attention to consistency of lettering style and overall spacing is important.

e. Lettering for railroads, roads, and waterways on maps should be parallel and close to the symbol.

f. An important part of the map composition is positioning of labels. A name is placed near its feature and with minimum interference with other map detail.

g. Variations of size and letter fonts help to identify and differentiate between types of map features.

Figure 10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Objective 14

Useful tools for the creation and production of maps and plans

a. Stereoscope viewers—Used to read aerial photographs in stereo (3-dimension)

b. Aerial photographs—Used to verify locations of points on the earth

c. Orthophotographs—Used as a base map for line art to show plans for a specific area

d. Map separates—USGS 7.5 minute quadrangle maps are available in color separates. These may be purchased for use as a base map for new information.

- Available in six separates or any combination of the following:
  - Black: cultural features, boundaries, and names
  - Blue: water features
  - Red: highway classifications, fence lines, built up areas, U.S. public survey lines
  - Green: areas of vegetation
  - Brown: topographic features
  - Purple: photo revised data, not field checked
- Available in many different USGS map scales

e. Spreadsheets—Used for preparation of data or calculations such as earthwork or curve information

f. Cartographic data—Available through CD-ROM or download files from the Internet

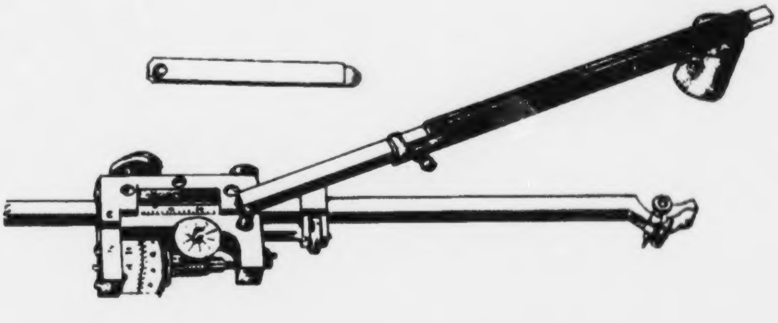
g. Planimeter—A tool used to determine approximate area of a mapped area

Objective 15

Types of planimeters

a. Polar planimeter—Has a fixed or adjustable arm

Figure 11



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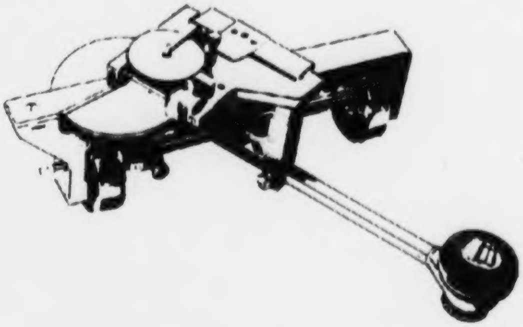
- Fixed arm planimeter—Measures areas in square inches (in^2) or square centimeters (cm^2), then multiplied by a factor
- Adjustable arm planimeter—Can be set to a variety of ratios for direct reading from the dial

b. Disc planimeter

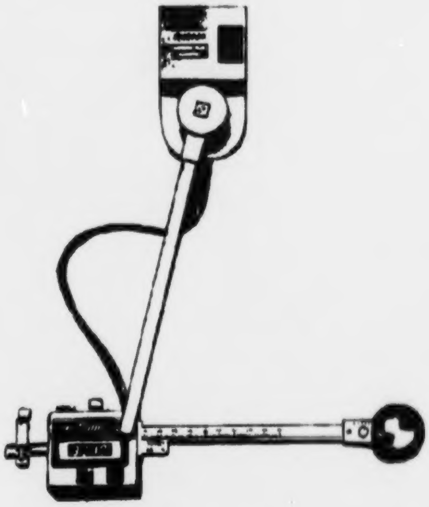
Figure 12



- Is considered more precise than the polar planimeter
- Is recommended for use on maps or charts that have been reduced to a small scale

c. Electronic planimeter

Figure 13

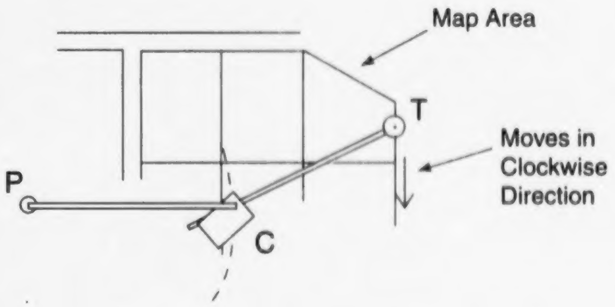


- Has a digital readout of the area measured
- Minimizes the possibility of decimal mistakes
- Can be instantly set on zero

Objective 16

Parts of a polar planimeter

Figure 14



a. Tracer (T)—A metal pointer or dot on a magnifying glass

b. Pole (P)—A weighted, fixed point used to hold the planimeter in place

c. Counter box (C)

- Has a socket into which pivot (B) and the end of the polar bar (PB) rest
- Allows the two arms to rotate around the pole (P)
- Contains a dial that rolls forward and backwards as the pointer follows the outline
- The dial registers the number of revolutions to the nearest 0.01 revolutions

Objective 17

Applications of aerial photography

a. Photo interpretation—The analysis of aerial photographs for the identification and measurement of surface objects and features

b. Stereo compilation—To extract precisely located feature information from aerial photography

c. Orthophotography—All information not found on the photo are overprinted onto the photo (then known as photomap)

d. Analytical aerotriangulation—Producing coordinates of photo control points by mathematical procedures rather than by analog methods

e. Photo mosaic—A series of aerial photographs that are taken along a given flight combined into one large photograph; constructed by matching images that appear on overlapping photographs

Note: Because of the distortion found around the edges of a single aerial photo, it is necessary to group many together to obtain a less distorted view of an area of land.

Objective 18

Advantages and disadvantages of using aerial photography for mapping work

a. Advantages

- Speed at which work is accomplished
- Wealth of detail secured
- Access to areas difficult to reach by ground

b. Disadvantages

- Cost of flying a project
- Availability of aerial photos for all areas
- Distortion around edges of aerial photos due to curvature of the earth
- Does not pick up utilities or pipe
- Not accurate in wooded areas

Objective 19

Aerial photo control

a. Control points for the survey are located in the field, identified and marked on the photo, and used to set up a stereo model

b. Horizontal control for a stereo model

- A baseline measurement of two clearly identifiable points from the ground within the model area is required.
- This baseline should be long enough to measure three or more inches on the photo.
- Baseline measurement should be provided every third or fourth model.

c. Vertical control for a stereo model

- Four vertical control points, one near each corner of the model, are required.
- Vertical control is determined by differential leveling or trigonometric leveling.

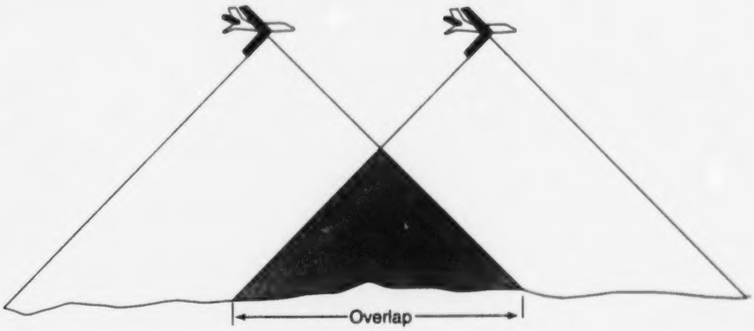
Objective 20

General facts about aerial photogrammetry

a. Aerial photos of most of the United States are available for a fee through federal, state, and local government agencies.

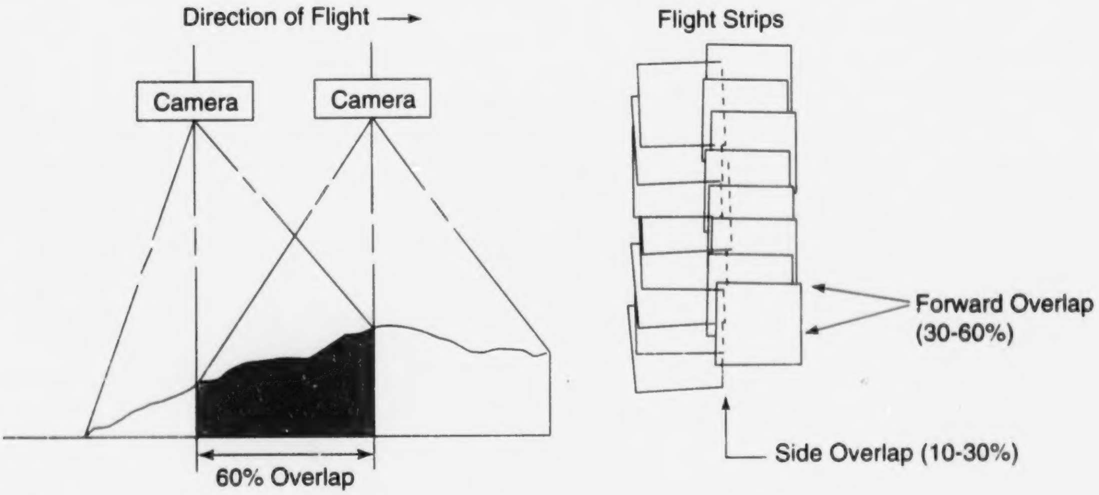
b. Photographs may be taken from airplanes, satellites, or ground stations.

Figure 15



c. Aerial photographs are taken in sequential order, usually with 30 to 60 percent forward overlap and 10 to 30 percent side overlap.

Figure 16


Direction of Flight →
Camera
Camera
60% Overlap
Flight Strips
Forward Overlap
(30-60%)
Side Overlap (10-30%)

d. Scale of the aerial photograph

- Is identified prior to taking a photograph
- Factors in scale selection include:
  - Use
  - Size
  - Shape
  - Financial resources
- The scale of the aerial photo is the ratio of the camera focal length to the height of the flight above ground.

$$\text{Scale (RF)} \; \frac{\text{Photo Distance}}{\text{Ground Distance}}$$

e. Stereoviewing of aerial photographs requires the projection of two or more overlapping images, which creates a 3-dimensional model

Objective 21

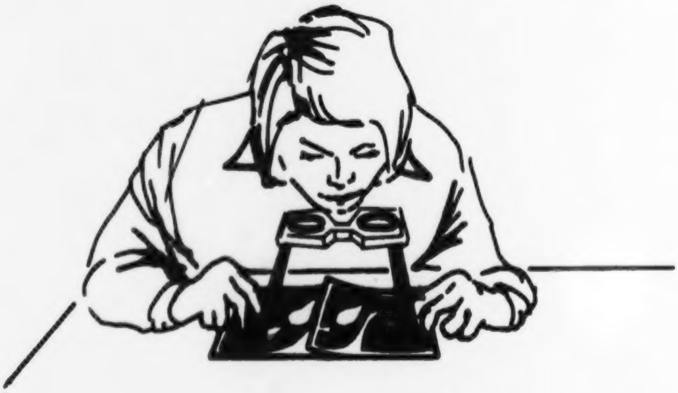
Steps for using a stereoscope

a. Line up the adjoining aerial photographs with common features lined up.

Note: Use one landmark to help line up the photos correctly.

b. Slightly overlap the two photos and set the stereoscope on the photos straddling the overlap.

Figure 17



c. Look through the viewers and fix on the landmark. You should see two images of the landmark. (One appears to float.)

d. Maneuver the photo so the two images line up, one on top of the other. At this time you should see the photo images in three dimension (3-D).

Information Sheet

Objective 22

Common mistakes made in map drafting

a. Not checking scaling distances when plotting coordinates

b. Plotting by protractor, not a computer

c. Selecting an inappropriate scale or contour interval for the map

d. Improperly orienting topographic notes in field or office

e. Making the north arrow too large, complex, or black

f. Omitting the scale or necessary notes

g. Failing to balance the sheet by making a preliminary sketch

h. Drafting the map on a poor-quality medium

Objective 23

Assignment Sheet 1—Complete a Tracing in Ink of a Mapped Area

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Balance of map	______
• Line quality	______
• Assignment sheet is neat and legible	______

Basic Skills

Reading   Critical Thinking

Directions

Using the layout for the "missile complex" completed in Unit 6, Assignment Sheet 6, set up a final map for presentation.

1. Determine final sheet size for map to be drafted.
2. Complete in ink on film.

   Note: Determine line weights with your instructor.
3. Include all necessary information:
   a. Title block and border
   b. Legend
   c. North meridian
   d. Graphic scale
   e. Notes
4. Hand letter dimensions in ink.
5. Use mechanical lettering or press-on letters for the title block information.
6. Run diazo print.

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Objective 24

Assignment Sheet 2—Prepare a Final Presentation of the MAVCC Topographic Survey Map

Name ______________________ Overall Rating ________

Date ______________________

Evaluation Criteria	Rating
• Completeness of map	______
• Balance of map components	______
• Appropriate line weights	______

Basic Skills

Reading Critical Thinking Technology

Given: All the components created by the computer for the MAVCC topographic survey map

Directions

Arrange all the map components on a map sheet. Set up for ease of readability. Create and place a north arrow, legend, and title block in their appropriate positions.

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Objective 25

Job Sheet 1—Use a Polar Planimeter to Determine Acreage

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Planimeter is set up correctly	______
• Dial readings are read accurately	______
• Correct measurement for area is made	______

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Polar planimeter
- Map area to be measured
- Paper and pencil for recording results

Procedure

☐ 1. Set planimeter in place. Position pole outside the area to be measured. Test to see if the tracer arm can reach all around the area to be measured.

Note: If area is too large for one swing around it, establish one or more division lines. Planimeter each part and add them together.

☐ 2. Zero up the dials or read the initial reading and record.

Note: Refer to the manual for instructions on how to operate your planimeter.

☐ 3. Trace around area to be measured in a clockwise direction.

☐ 4. Record the number on the dial.

- Fixed arm planimeter: If length or tracer arm (AT) is set without the ability to adjust, it is usually set at a ratio of 1:10.

  Example: 1″ x 1″ square = 1.00 revolutions
  Therefore, area traced = Number of revolutions x 10

- For planimeter with adjustable arm, allow for different settings.

  Example: 1″ = 20 up to 1″ = 200′
  Set for a linear scale means 1 square inch = 400 square feet.

☐ 5. If using a fixed arm planimeter, multiply your number of revolutions by the number of square feet (at map scale).

Example: If map scale is 1″ = 50′, then 1 square inch on map = 2500 sq. ft.
Number of square feet x number of revolutions = Total sq. ft.
2500 sq. ft. x 1 revolution = 2500 sq. ft.

☐ 6. Divide the number of square feet in one acre (43,560 sq. ft. in 1 acre) into the number of square feet of the area being measured. This will give you the number of acres in the area to be measured.

Example: 2500 sq. ft. ÷ 43,500 sq. ft. = .057 acres

☐ 7. For greater accuracy of results, planimeter each area three times and average the results.

Evaluator's Comments: ______________________________

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